WATER WORKS AND SEWERAGE

March, 1933 — Editor — Vol. LXXX. No. 3

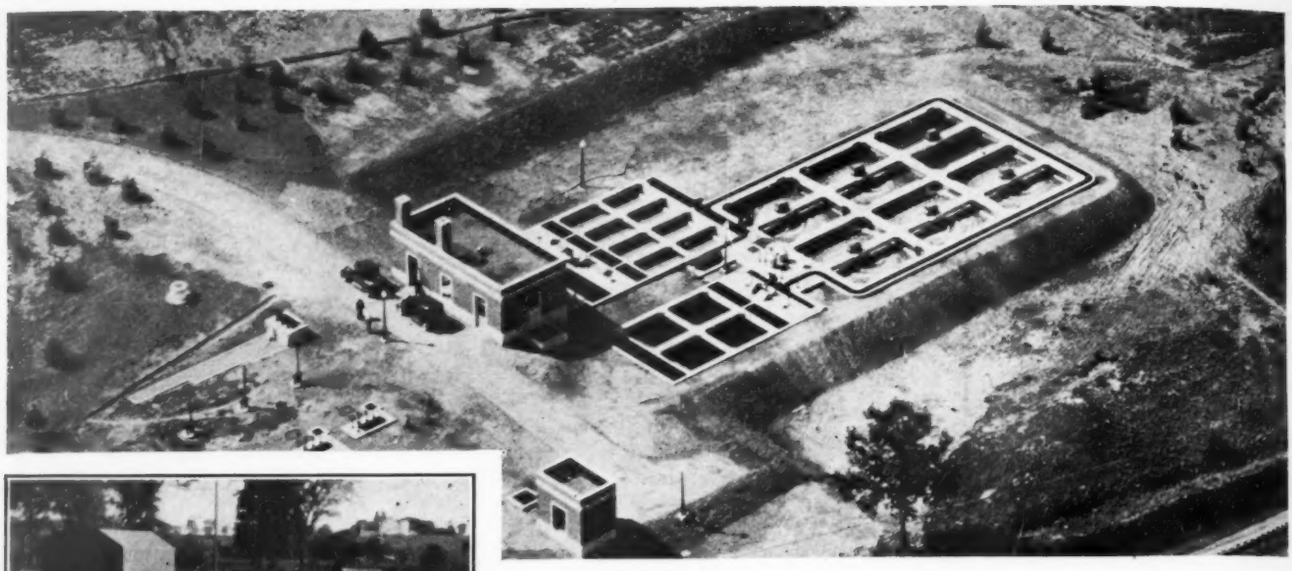
Princeton, N. J. Sewage Treatment Works: View across Secondary Sedimentation Tank, Showing Head House and Sludge Drying Beds.

IN THIS ISSUE

Economic Significance of Pipe Linings
Clarification of Sewage with Ferric Chloride
New Sewage Treatment Plant at Princeton, N. J.
Large Scale Sludge Digestion Experiments at Baltimore
Water Treatment on Pacific Lines of Southern Pacific Ry.
Evaluation of Powdered Activated Carbon for Water Works

PENNSYLVANIA'S SECOND ACTIVATED SLUDGE PLANT EQUIPPED WITH SIMPLEX MECHANICAL SURFACE AERATORS

PENNHURST STATE SCHOOL SEWAGE TREATMENT PLANT



WM. H. DECHANT & SONS, Reading, Pa., Cons. Engr.

Simplex Aerator unit in operation

Treating a strong institutional waste SIMPLEX AERATORS are again giving results that more than justify their selection.

Interesting Data on request.

SIMPLEX SEWAGE EQUIPMENT

AERATORS — CLARIFIERS
METERS — DIGESTORS
GAUGES — GAS BOILERS
SLUDGE CONTROLLERS
REVOLVING DISTRIBUTORS

May We Help You?

SIMPLEX VALVE AND METER CO.

6743 UPLAND ST. PHILADELPHIA, PA.

EASTERN REPRESENTATIVES FOR SIMPLEX EJECTOR & AERATOR CORP.

SIMPLEX — UNIFORM — MOVES PROPORTIONALLY TO RATE OF FLOW

TRADE MARK Reg. U. S. Pat. Off.

DOING ONE THING WELL

EBG

Liquid Chlorine

Look for the RED Cylinder

ELECTRO BLEACHING GAS CO.

Pioneer Manufacturer of Liquid Chlorine

Main Office: 9 East 41st Street, New York, N. Y.

Plant: Niagara Falls, N. Y.

AN ANSWER TO THE QUESTION:
"WHAT IS THE MEANING OF pH?"

pH *And Its* Practical Application

By *Frank L. LaMotte*
William R. Kenny
Allen B. Reed

Table of Contents

Section A. Mechanism of Hydrogen Ion Determinations

I—Introduction and Preliminary Discussion
II—Hydrogen and Hydroxyl Ions
III—Buffer Action
IV—Determination of pH
V—Sources of Error

Section B. Practical Application of Hydrogen Ion Determinations in Industry and Science

VI—Municipal and Industrial Water Supply
VII—Water Corrosion Problems
VIII—Disposal of Sewage and Industrial Waste
IX—Sugar Industry
X—Gelatin and Glue
XI—Leather Manufacture
XII—Textile Industry
XIII—Pulp and Paper Industry
XIV—Food Industries
XV—Cleaning Processes
XVI—Electrodeposition of Metals
XVII—General Industrial Chemistry
XVIII—Bacteriology, Pathology, and Titration Procedures
XIX—Soils

$3.50

Cloth bound, 6x9, 255 Pages, Original Control Charts, Illustrated, Indexed.

The charts alone are well worth the price of this book.

TODAY the term "pH" is part of the routine vocabulary of almost every technical man, and the usefulness of the subject has benefited so many processes that it is now an accepted operating factor. So rapid has been its adoption throughout the technical world, that a great many routine workers now using some means of pH control do not have a clear understanding of the term "pH" itself, nor of the simple underlying principles involved in its measurement.

It is the purpose of this book to supply the need for such fundamental information in simple language, avoiding technical terms as much as possible.

Scientific men whose early training has not included this phase of chemistry and operating men will find "pH And Its Practical Application" to be a *practical* book for any reader who is not particularly interested in the theoretical aspects of hydrogen in concentration.

The broad scope of the book is indicated by the Table of Contents.

GILLETTE BOOK COMPANY
400 W. Madison Street
CHICAGO, ILLINOIS

------ USE THIS COUPON ----------

Name .....
Position .....
Company .....
Address .....
City..... State.....

WWS-3-33

GILLETTE BOOK COMPANY,
400 W. Madison St., Chicago, Ill.

I should like to have "pH And Its Practical Application" on 10 days' free trial. At the end of that time I will remit $3.50 or return the book, postpaid.

WATER WORKS & SEWERAGE

L. H. ENSLOW, Editor

LEADING ARTICLES To Appear in the Next and Subsequent Issues:

Marsden C. Smith, Engineer of Utilities, Richmond, Va., in his article on "The Use of the Ammonia Chlorine Process at Richmond, Va.," discloses difficulties encountered, means of correction and the effective results secured from the process in the end. In addition to taste prevention and insuring safe water to the far ends of the pipe system, the use of ammonia at Richmond has alleviated red water troubles and putrifaction in dead ends.

Sheppard T. Powell, Consulting Chemical Engineer of Baltimore, Md., will discuss "Water Supply Practice in Oil Refining Operations"—including methods employed for treatment and conditioning of the water used.

A. F. Porzelius, Superintendent, City Water Company of Chattanooga, Tenn., will give some valuable suggestions and hints on the important topic of "Selling the Water Works to the Public." Good-will is frequently almost as essential as good water, and the author tells from experience, how it may be secured.

Robert B. Morse, Chief Engineer of the Washington Suburban Sanitary Districts, Hyattesville, Md., will relate developments wherein the use of light weight cast iron pipe in large diameter sewer construction and for lateral house construction in the Washington suburban district has led to economy, simplified construction and increased carrying capacities. Permanency of structure and other miscellaneous advantages are cited as reasons for selecting cast iron pipe for the Washington suburban projects.

Louis A. Geupel, Water Purification Engineer, formerly in charge of construction and operation of the new filtration plant at Athens, Greece, will describe the Athens plant and recount operating conditions met with. One unique feature of the plant is the system employed for recovering the wash water.

Herbert H. Brown, Engineer of Design and Construction, Milwaukee Water Department, will tell how Milwaukee is solving a distribution problem. The plan under development is novel in water works practice — employing ground water storage and automatically operated auxiliary pumps, strategically located to maintain pressures on the system during heavy draught periods.

Weston Gavett, Consulting Engineer of New York City, will describe an ingenious but simple constant head flow meter designed by the author and now in successful use at a sewage treatment plant.

Vol. LXXX, No. 3

CONTENTS for MARCH 1933

Economic Significance of Pipe Linings 73
By ELSON T. KILLAM
Designing Engineer: Associate Alexander Potter, Consulting Engineer, New York City.

New Treatment Plant at Princeton, N. J., Unifies Sewage Disposal. 77
By TRUMAN M. CURRY, JR.
Associate Engineer with Nicholas S. Hill, Jr., Consulting Engineer, New York City.

Large Scale Sludge Digestion Experiments at Baltimore 81
By C. E. KEEFER
Principal Assistant Engineer, Bureau of Sewers, Baltimore, Md.

Evaluation of Powdered Activated Carbon for Water Works—A Discussion 86
By MARTIN E. FLENTJE
Superintendent of Purification, Community Water Service Co., New York City.

Clarification of Sewage with Ferric Chloride—Developments at Palo Alto, Calif. 89
By RALPH A. STEVENSON
Research Engineer, Great Western Electro-Chemical Co., Pittsburg, Calif.

Water Treatment on Pacific Lines of Southern Pacific Ry. 92
By DENNISTOUN WOOD
Engineer of Tests, Southern Pacific Ry. Co., San Francisco, Calif.

Tile Sludge Removal Systems for Water Treatment Plants 95
By EDWARD P. SCHINMAN
Chemical Engineer, The Permutit Co., New York City.

Digest of Papers on Sewer Topics at 15th Annual Texas Water Works Short School 97

Notes on Sewage Gas and a Simple Method of Analysis 99
By CHARLES C. AGAR
Assistant Sanitary Engineer, New York State Department of Health, Albany, N. Y.

Overcoming the Cost of Obsolescence at a Water Pumping Plant. 100
By J. BRYAN MILLER
City Manager, Jacksonville, Tex.

Why Bidding Prices on Portland Cement Are Uniform 101
By HALBERT P. GILLETTE
Editor-in-Chief, Gillette Publishing Co., Chicago.

Mechanical Agitation by Motor Driven Paddles at Winnetka, Ill. 103
By CARL LEIPOLD
Superintendent Water Filtration Plant, Winnetka, Ill.

Water Softening Plant at Western Springs, Ill. 105
By DONALD H. MAXWELL
Of Alvord, Burdick & Howson, Consulting Engineers, Chicago, Ill.

The Cause of Variation in the "Solar Constant" 109
By HALBERT P. GILLETTE
Editor-in-Chief, Gillette Publishing Co., Chicago, Ill.

Editorial 110

New Equipment and Materials 111

With the Manufacturers 112

Published monthly by the GILLETTE PUBLISHING CO., Daily News Building, Chicago, Ill.

Entered as Second Class Matter, June 2, 1931, at the Post Office at Chicago, Ill., under the Act of March 3, 1879. Published monthly at 400 W. Madison Street, Chicago, Ill. Per copy 25c. Subscription rates $2.00 per year. Canadian and Foreign, $3.00 per year. Copyright, 1933, by Gillette Publishing Company, Publishers of: Water Works and Sewerage, Roads and Streets, Oil and Soap, Motive Power, The Art of Mosaics and Terrazzo, Road and Street Catalog and Data Book, Water Works Catalog and Data Book.

HALBERT P. GILLETTE, Pres. and Editor in Chief; E. S. GILLETTE, Vice-Pres. and Secretary; E. C. KELLY, Vice-President; J. M. ANGELL, JR., Eastern Manager; L. H. ENSLOW, 420 Lexington Ave., New York, N. Y., Editor; C. T. MURRAY, Managing Editor; V. J. BROWN, Associate Editor; JOHN R. BAYLIS, Associate Editor; D. G. LEDGERWOOD, Make-Up Editor.

Chicago Office, Daily News Building. Cleveland Office, 953 Leader Bldg. New York Office, 420 Lexington Ave. San Francisco Office, 703 Market Street.

Addresses will be changed as frequently as desired, upon notification; not otherwise. Changes of address should be sent in at least two weeks before the date of the next issue of *Water Works and Sewerage*, in order for them to be effective for that number. Immediate notice should be given of any delay in the receipt of the magazine.

ADVERTISERS IN THIS ISSUE

A

Abrams Aerial Survey Corp..... 52
Acorn Iron & Metal Co..... 51
Alvord, Burdick & Howson..... 52

B

Black & Veatch..... 52
Burns & McDonnell Engr. Co..... 52

C

Chester Engrs., J. N., The..... 52
Chicago Testing Laboratory..... 52
Chute, H. O..... 52
Clark, Wm. G..... 52
Cleveland, H. Burdett..... 52

D

Dorr Co., Inc., The.....Third Cover
Dow, A. W..... 52

E

Electro Bleaching Gas Co..... 3

F

Filtration Equipment Corp..... 49
Fowler, Chas. Evan..... 52
Fuller & McClintock..... 52

G

Gillette Publishing Co.....4-7-51
Gordon & Bulot..... 52

H

Hall, B. M., & Sons..... 52
Hellige, Inc. 49
Hill, Nicholas S., Jr..... 52

I

Industrial Chemical Sales Co., Inc..... 8

K

Kimberly, A. Elliott..... 52
Knowles, Inc., Morris..... 52

L

Lock Joint Pipe Co..... 51

M

McWane Cast Iron Pipe Co..... 51
Metcalf & Eddy..... 52

N

National Water Main Cleaning Co..... 49

P

Pacific States Cast Iron Pipe Co..... 51
Phipps & Bird, Inc..... 49
Pirnie, Malcolm 52
Potter, Alexander 52
Powell, Sheppard T..... 52

R

Roberts Filter Mfg. Co..... 51
Rosing, Astrid S., Inc..... 52

S

Simplex Valve & Meter Co.....Second Cover
South Bend Foundry Co..... 51
Stewart, W. H..... 50

T

Tamms Silica Co..... 51
Taylor Audit Co., P. H..... 52

W

Wallace & Tiernan.....Back Cover

Announcing a NEW BOOK

that every water works operator should have

WATER PURIFICATION CONTROL

I COAGULATION
Time of Mixing, Floc Characteristics, pH Control, Color Removal, Iron and Lime Coagulation, Use of Sodium Aluminate, Manganese, Coagulation Control.

II SEDIMENTATION
Effect of Settling on Plant Control, Cross-Baffled Basins.

III FILTRATION
Filter Beds, Rate Controllers, Filter Washing, Care of Filter Beds, Mud Deposit Formation, Sand Grading, Air Binding, Sand Cleaning, Filter Control Records.

IV DISINFECTION
Chlorination, Ultra Violet Ray and Ozone Treatment.

V TASTES AND ODORS
Superchlorination, Chloramines, Activated Carbon, Aeration, Permanganate, Algae Control.

VI CORRECTIVE TREATMENT
pH Control, Effect of Corrective Treatment.

VII PLANT CONTROL DATA
Standards of Purity.

$1.75
POST PAID

A Short, Non-Technical, Informative, Practical Handbook and Guide for the Plant Operator

By
EDWARD S. HOPKINS
Principal Sanitary Chemist, Bureau of Water Supply, Baltimore, Md.

THIS is a handbook for which there has been genuine need in the water-works field for a number of years. Its audience is the plant operator. It is particularly designed to meet his needs. It is a book of simple discussion and simple directions. It aims to present the practical, usable facts in systematic form.

ABEL WOLMAN SAYS: "The number of texts of a purely operating character is decidedly limited. Those that are good are somewhat out of date, and therefore, this volume fills a current need.

"No matter how well designed a water treatment plant may be, its product is dependent to a great degree upon the efficiency of the man operating it. To improve and guide the operator is the primary function of this book. It is designed, in simplicity of language and arrangement, to meet the needs of the rank and file. It should lighten the load on many control agencies and should stimulate the already conscientious operator, whose task is so well done and so rarely given public recognition, to higher levels of performance. The book should be on each operator's desk."

—Excerpts from the Foreword

USE THE COUPON

WATER WORKS AND SEWERAGE
400 W. Madison St., Chicago, Ill.

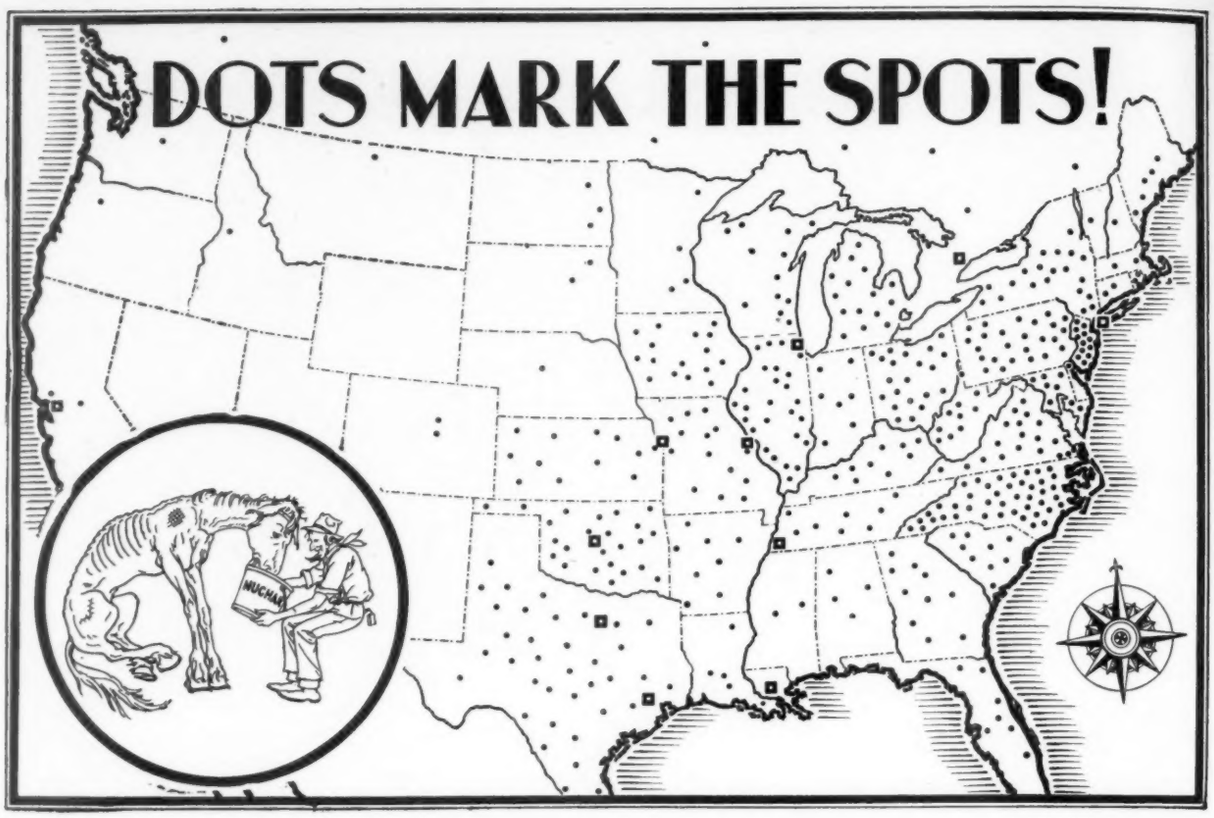
Gentlemen:

Please mail me a copy of WATER PURIFICATION CONTROL. My check or money order for $1.75 is enclosed.

NAME .....

POSITION .....

ADDRESS 3-33



EACH dot marks a spot where the City Water Supply, like the old gray mare, "Ain't what it used to be."

Maybe it was good water at one time—clear, pure and sparkling. Then something happened—algae, dead fish, industrial waste, or what not, which caused the water to taste bad and smell "to high heaven" and complaints started pouring in.

The Mayor, the Water Commissioners, the Superintendent and the Chemists all tried every known remedy and finally, as a last resort, they tried powdered activated carbon "NUCHAR," and the trick was done.

Tastes and odors disappeared, complaints ceased, amicable relations between the consuming public and officials were resumed.

There are now over 400 plants buying and using "NUCHAR" regularly and two years ago less than 20 plants used it.

The growth of the use of "NUCHAR" has been steady and by some authorities has been pronounced the most outstanding development in the water field in recent years.

The reason for this development cannot be credited to high powered salesmanship but to the fact that, like the home-town boy, " 'NUCHAR' makes good" under practically all conditions and has been freely discussed at Conventions and in the field by water officials.

Get in line this year. Keep abreast of the times. Order "NUCHAR" now and use it daily as insurance against taste and odor trouble.

INDUSTRIAL CHEMICAL SALES CO., Inc.

230 Park Avenue, New York, N. Y. — 205 W. Wacker Drive, Chicago, Ill.

POWDERED ACTIVATED AQUA NUCHAR CARBON

WATER WORKS AND SEWERAGE
MAR. 1933
VOL. 80 No. 3
A GILLETTE PUBLICATION

ECONOMIC SIGNIFICANCE OF PIPE LININGS

By ELSON T. KILLAM
Designing Engineer.

Elson T. Killam

DIFFICULTIES in the authorization and sale of municipal bonds for water works and for sewerage works during recent months, together with high rates of interest on capital expenditure, will have a decided influence on future policies of design and construction, with the result that particular consideration must be given to all possible methods of economy.

An outstanding opportunity of securing economy in the design and construction of water works and sewerage projects is in the perfection and use of pipe linings which will increase the initial carrying capacity of the pipe line and result in maintenance of the initial capacity of the line throughout a reasonably long period of service.

Consideration of the life of a pipe line is often erroneously limited to consideration of the life of the material. It has, of course, been demonstrated that under ordinary conditions, the structural life of any of the commonly used materials will substantially exceed the period covered by bond issues under which pipe lines are ordinarily financed. The most essential consideration regarding the life of a pipe line, however, is the permanence of the initial carrying capacity, for the value of any pipe line can be measured not solely by its structural integrity after service, but to a far greater degree, by its carrying capacity.

It is universally recognized that the capacity of pipe lines is progressively reduced from year to year, whereas the capacity demand is in nearly every case, progressively increased. The opposing trend of actual capacity vs. required capacity, shown on Fig. I, illustrates a major economic waste which warrants the fullest consideration of all feasible methods for elimination of such conditions. Referring to the graph, it will be seen that if the rate of tuberculation should be equivalent to the average rate suggested in Hazen-Williams Tables, then the demand would equal available capacity in 20 years at 77 per cent of the designed 30-year capacity. If the rate of tuberculation is equivalent to the rate in the Coolgardie pipe line, then the demand would equal the capacity in 11 years at 60 per cent of the designed 30-year capacity.

Figure I, of course, represents a hypothetical case only, and the loss of capacity with age will vary most substantially with the quality of water in any particular system. However, this opposing trend is so common, and the effects assume such economic importance, that the matter deserves most careful consideration.

Basic Reasons for Consideration of Lining and Operating Difficulties with Unlined Pipe

There are several basic reasons compelling the serious consideration of the adoption of some satisfactory type of pipe lining to eliminate uncertainty in design and difficulties arising from loss of capacity by tuberculation.

First: Due to the wide variation in the relative capacity reduction by tuberculation in different systems, the use of unlined pipe necessitates the assumption of friction coefficients which, even when tempered by the best engineering judgment and experience, should, in all frankness, be termed guess-work. Thus, while it is entirely feasible to accurately determine the coefficient of a new pipe line of any given material, and with any given internal surface, the probable condition

[1]Associate, Alexander Potter, Consulting Engineer, New York, N. Y.

of unlined pipe after service is very problematical. It follows that any variation from the assumed condition results in loss of economy, not alone in first cost, but also in cost of maintenance and operation.

Second: When pipes are not lined, the necessity for providing larger diameter pipe, to offset the reduction of capacity due to tuberculation, results in a substantial increase in cost of construction.

Third: The increase in congestion of underground structures in cities, and the rapid progressive extension of improved paving, demands further advance in standards of construction of pipe lines, to the end that necessary replacement of mains, due to inadequate capacity, may be reduced to an amount substantially below requirements under present practice.

Fourth: The tuberculation and reduction of capacity of pipe lines, create operating difficulties and inefficient operation, examples of which are as follows:

(a) Increased power cost, due to increase in friction head in force mains from pumping stations.

(b) Inefficient operation of pumps and motors. Change of pumping head due to tuberculation may, particularly when friction head is a substantial portion of the total dynamic head, seriously upset the designed relation of head discharge and efficiency, to a degree which will make the pumping unit inefficient and inadequate. For instance, if the actual friction head exceeds the design condition, then a reduction of pump capacity, usually accompanied by a shift in horsepower requirements away from the point of maximum efficiency, will ordinarily occur. If, on the other hand, the pump and motor have been designed for the relatively high friction head which occurs with badly tuberculated mains, then during the first years of operation, the actual head will be lower than the design head with a coincident increase in capacity and in horsepower, and with a consequent loss of efficiency. The uncertainty as to probable conditions ordinarily requires a liberal allowance in the selection of a proper commercial size of motor, and the large factor of safety often results in continuous loss in pump and motor efficiencies.

(c) Tuberculation of unlined pipe has the inevitable result of creating inadequate capacity of distribution systems for fire flow, and reinforcement and enlargement of the many miles of small pipe under paved streets in a distribution system, involves a tremendous expense.

(d) Rusty water necessitates frequent flushing, and occasional abnormal draft on tuberculated mains often affects the quality of the water, temporarily at least, to a degree resulting in damage to industrial consumers.

Available Pipe Linings

Conditions stated above will vary with the aggressiveness of the water and therefore the rate of tuberculation; but these conditions are sufficiently important and are so prevalent as to focus attention on the value of pipe linings.

The two types of lining most widely used at the present time, are cement lining and bitumastic lining, both centrifugally applied. While neither type can be considered perfect in every detail and under all conditions, nevertheless both types have been developed to a point where they are commercially available, at comparatively low cost in relation to the benefits derived, and I believe it can properly be said that, with certain precautions of comparatively minor importance, these two types of lining will be found effectively successful. The use of either type of lining will result in an increase in the initial capacity of the pipe over that of an unlined pipe, which will be substantially maintained. The cost of such linings is more than absorbed by the additional capacity obtained, either by creating greater capacity for a pipe of fixed diameter, or by making it feasable to use a smaller diameter pipe for a predetermined requirement.

In the following paragraphs, the pertinent features of both cement and bitumastic linings are discussed.

Method of Application of Cement Lining:—Cement Lining

Cement lining was first applied centrifugally in 1922 as a result of a suggestion of James Gibson, Superintendent of the Water Department at Charleston, S. C. The lining material consists of a mortar mixed in the proportion of 3 parts of portland cement to 1 part screened sand, by volume, together with the minimum amount of water required for proper consistency. The mortar is placed in a trough mounted as a cantilever on a 4-wheel carriage, and the pipe is set on rollers and revolved with

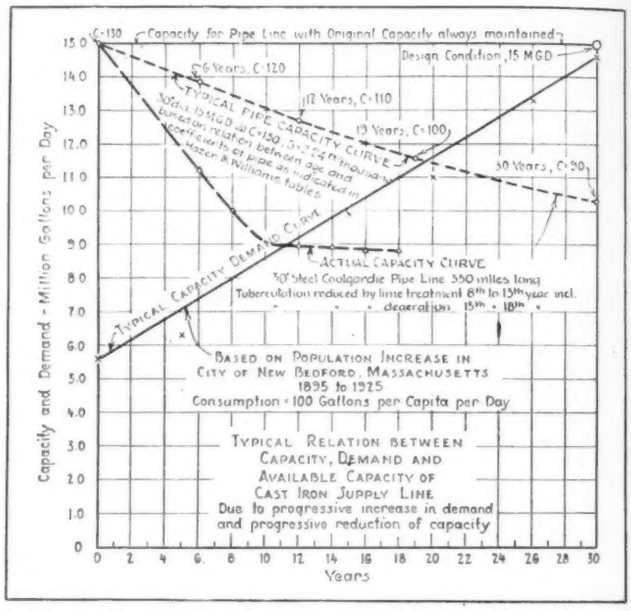

C-130 Capacity for Pipe Line with Original Capacity always maintained
Design Condition, 15 MGD
6 Years, C-120
12 Years, C-110
TYPICAL FIRE CAPACITY CURVE
18 Years, C-100
30 Years, C-90
ACTUAL CAPACITY CURVE
TYPICAL CAPACITY DEMAND CURVE
Based on Population Increase in City of New Bedford, Massachusetts 1895 to 1925
Consumption = 100 Gallons per Capita per Day
Typical Relation between Capacity, Demand and Available Capacity of Cast Iron Supply Line
Due to progressive increase in demand and progressive reduction of capacity
Capacity and Demand - Million Gallons per Day
Years

Fig. 1.—Relation Between Capacity Demand and Available Capacity of C. I. Pipe

a peripheral speed of approximately 300 ft. per minute. When proper speed has been developed, the trough is inserted for the full length of the pipe and the mortar is distributed. The pipe is then stopped, the lining inspected, and any bare spots are covered, whereupon the pipe is again revolved at a peripheral speed of 600 ft. per minute, until the lining is properly set. The pipe must be kept damp for at least 24 hours, and no shipment should be made for at least 48 hours.

Pipe thus lined are not coated inside with the ordinary tar dip, but are thoroughly cleaned and hydrostatically tested before lining. After lining, the pipe exterior is coated with tar or asphalt dip, brushed or sprayed on.

Thickness of Cement Lining

The American Standards Committee specifications stipulate the following thicknesses of lining, with an allowed plus tolerance of ⅛ in. on all sizes 4 in. to 24 in. in diameter, with no minus tolerance allowed.

4 in. to 12 in. dia. pipe inclusive....	⅛ in. thick
16 in. to 24 in. dia. pipe inclusive...	3/16 in. thick

Minor Difficulties Reported with Cement Lining

The minor difficulties which have been encountered with cement lining are as follows:

1. In certain instances with a rich lining mixture, the bond between the pipe and the lining has loosened, the entire lining ring pulling away from the pipe surface. In other instances, the bond with the pipe as a whole has been maintained, but crazing and cracking of the lining has occurred to a limited extent. Precautions against exposing lined pipe to a wide range of temperature will largely offset any destruction of the bond except to a limited degree due to shrinkage on setting.

2. In some localities complaints have arisen relative to the taste and appearance of water due to the initial dissolving of the lining. (See Journal N. E. W. W. A., December, 1928, Report of Committee on Cement Lined Pipe.)

The conclusion of this committee was substantially as follows: "While it is true that certain waters attack cement linings and cause water of disagreeable appearance, this condition has no hygienic significance and while the amount of lining dissolved is at times considerable, the rate of solution progressively reduces. Experience and practice has indicated a long life for cement lined surfaces, and a long life for proper cement linings in cast iron pipes is thereby indicated. Apparently the only waters having a dissolving effect are soft waters containing alkaline carbonate and little carbon dioxide, and experience indicates a great difference in solubility of linings, depending upon the quality of water."

The report suggests chemical treatment at small expense to reduce solvent action.

Cost of Cement Lining

The cost of cement lining is illustrated by quotations and bids in the following tabulation:

COST OF CEMENT LININGS

Quotations, March, 1926

Size of pipe, inches.	R. D. Wood & Co.	U. S. C. I. P. Co.	Quotations, July, 1931.	Low bidder 25 miles distribution system, Passaic, N. J., July, 1931.	Average 16 bids, Parsippany, N. J., July, 1931.	U. S. Cast Iron Pipe Co., Dec., 1932.
4	$0.06	$0.05	$0.04	.....	.....	$0.05
6	.0667	.0667	.0533	$0.055	$0.0547	.08
8	.095	.095	.076	.0744	.0778	.12
10	.13	.13	.104	.105	.1040	.16
12	.17	.17	.136	.135	.1321	.21
16	.19	.19	....	....	....	.23
20	.25	.25	....	....	....	.33
24	.33	.35	....	....	....	.44

RELATIVE INCREASE IN COST AND IN CAPACITY BY ADOPTION OF CEMENT LINING

Unlined Pipe Badly Tuberculated	"C" = 80	Relative Capacity 1.00
Unlined Pipe Average Tuberculation Conditions	"C" = 100	Relative Capacity 1.25
Unlined Pipe, New	"C" = 130	Relative Capacity 1.625
Cement Lined Pipe.....(a)	"C" = 140	Relative Capacity 1.75

(a) Although the coefficient with cement lining, based on actual diameter may be 145, this value is, under average conditions, reduced to approximately 140 by reason of the diameter reduction by the thickness of the lining.

Increase in Capacity

With a fixed friction loss, a cement lined pipe with a Williams-Hazen Coefficiency of "C" = 140, will have a capacity equal to:

(a) 108 per cent of the capacity of a new unlined cast iron pipe, having a coefficient of "C" = 130.

(b) 140 per cent of the capacity of an unlined cast iron pipe in average condition of tuberculation "C" = 100.

(c) 175 per cent of the capacity of an unlined cast iron pipe in badly tuberculated condition "C" = 80.

Increase in Cost

Based on bid prices for a 25-mile distribution system constructed late in 1931, with pipe from 6 in. to 12 in. in diameter, with a weighted diameter of 8.1 in., including cost of excavation and backfill, and furnishing and laying unlined pipe, the additional cost of cement lining bids varied from 6½ to 8 per cent.

Conclusions

A large tonnage of cast iron pipe has been lined with this type of lining and has generally given very satisfactory results. Tuberculation has been prevented and as shown in the preceding section, the increase in capacity much more than offsets the slight increase in cost.

If the comparison is made with a view of reducing the size of pipe by providing a lining, then it will be found in many cases that equivalent capacity at fixed head loss can be obtained at a substantial saving in cost by adoption of lined pipe of smaller diameter. As an illustration of this relation, it may be stated that a 20 in. cement lined pipe, with "C" = 140 will have the same capacity as a 24 in. pipe with "C" = 87; whereas the cost of the former, in place together with the lining, will be not more than 80 per cent of the cost of the latter, in place.

Bitumastic Enamel Lining

Bitumastic enamel, consisting of a coal-tar base in combination with an inert filler, has been widely specified in water supply and in marine work for many years, and the record of this material has been such as to test the permanence of its protective qualities.

This enamel has a melting point varying from 160 to 205 degrees F., depending upon the type of enamel required to meet temperature conditions up to the time the pipe is placed in the ground. Application of the hot molten enamel was confined to the hand brushing method until 1928, when the centrifugal method of application to pipe was developed. The development of the centrifugal method was of extreme importance, because, as a result this type of lining is available in a wide range of pipe sizes. Further, linings applied by this method have surfaces which are practically as smooth as glass, with a resulting Williams-Hazen coefficient which is higher than for any pipe surface previously available.

Despite the comparatively short period in which this method of application has been utilized, the range of pipe diameters to which lining has been thus applied varies from ½ in. pipe to 48 in. pipe, of lengths from 12 to 30 ft.

Method of Application of Bitumastic Lining

Bitumastic enamel is applied by practically the same method as is the cement lining.

The bare pipe is dipped or hand brushed with a coal-tar priming solution, and after the primer is thoroughly dried, the pipe is placed on a rolling machine and the hot enamel is poured into a trough extending the full length of the pipe. The pipe is then rotated at the proper speed required for the particular diameter being lined; the trough is dumped, and rotation is continued for 2 or 3 minutes until the lining is properly set. The speed of rotation is generally varied with the size of the pipe. Practice at the various foundries has shown them the best speed to use for each size.

The specified thickness of bitumastic enamel lining, has in most cases been 3/32nds of an inch for the full

range of sizes up to and including 30 in. steel pipe in 30 ft. lengths, with a plus or minus tolerance of 1/32nd of an inch.

Minor Difficulties Reported with Bitumastic Enamel Lining

1. In localities where pipe must be exposed to a wide range in temperature before being placed in the ground, it is necessary to coordinate shipment and pipe laying activities, in order that the lined pipe may not lay at the side of the trench and be exposed to a marked variation in temperature. While in general, coal tar products are considered more satisfactory as a protective coating than most grades of asphalt, the coal tar has one inherent difficulty, namely a much narrower temperature range between the high temperature softening point and the low temperature at which cracking may occur.

A material having a wide temperature range has been manufactured and is now under test, but at the present time, the above difficulties are being met in the following manner: Three types of enamel are manufactured. The "XXH" type (of high melting point) is used in cases where the pipe will be exposed to high temperature while laying in the sun in the summer season. The regular type enamel is used for pipe that will be laid during seasons of moderate temperature. In cases where the pipe is to be laid in freezing weather, a flux is added to the regular type enamel. Cracking at low temperature is thereby prevented.

From the experience of the writer, where shipment and pipe laying were properly coordinated, no difficulty has ensued in any case, but in other cases where pipe were left on the street throughout several seasons, without any protection, considerable damage to the enamel lining has occurred.

2. Where lead is used as the jointing material, it is necessary to carefully control the temperature of the lead, in order to prevent the melting of the lining within a small area (2 or 3 in. in diameter) directly under the pouring gate. (See Engineering News-Record. "Effect of Lead Joint Heat on Bituminous Pipe Lining," Aug. 18, 1932, page 199.)

3. Pipe lined with bitumastic materials is painted with whitewash before shipment in order to reduce heat absorption by the pipe. If this whitewash coating is destroyed and the pipe be exposed to the direct rays of the sun in hot weather, then softening and wrinkling of the enamel may occur.

4. The pipe must be protected during shipment to prevent workmen from walking through the large diameter pipe and furthermore to prevent hot cinders becoming embedded in the lining.

Cost of Bitumastic Enamel Lining

The cost of Bitumastic Enamel lining is illustrated by quotations and bids in the following tabulation:

Size of pipe, inches.	Avg. 16 bidders, Parsippany, N. J., July 30, 1931.	Low bid on lining, Parsippany, N. J., July 30, 1931.	Avg. 4 bids, Parsippany, N. J., Oct. 6, 1932.	Avg. bid, Newton, Mass., Aug., 1932.	Bid to New Haven Water Co., May, 1931.
6	$0.0686	$0.053	$0.0667	$0.075	.....
8	.0980	.076	.0967	.1078	.....
10	.1336	.104	.140	.1258	.....
12	.1885	.136	.....	.182	.....
16	.....	....	.....	.2741	$0.15
20	....	.....	.....	.....	.25
24	.....	....	.....	.....	.35
30	.....	....	.....	.....	.45
36	.....	....	.....	.....	.55

Tonnage.—Parsippany, N. J., 2,500 tons; Newton, Mass., 1,000 tons; New Haven Water Co., 10,000 tons.

RELATIVE INCREASE IN COST AND IN CAPACITY BY ADOPTION OF BITUMASTIC ENAMEL LINING

Unlined Pipe Badly Tuberculated	"C" = 80	Relative Capacity 1.00
Unlined Pipe Average Tuberculated Condition	"C" = 100	Relative Capacity 1.25
Unlined Pipe, New	"C" = 130	Relative Capacity 1.625
Bitumastic Enamel Lined Pipe (a)	"C" = 150	Relative Capacity 1.875

(a) Based on actual and nominal diameter, and comparable to values in Williams-Hazen Tables.

Increase in Capacity

With a fixed friction loss, a pipe lined with Bitumastic enamel having a Williams-Hazen coefficient "C" = 150, will have a capacity equal to

(a) 115 per cent of the capacity of a new unlined cast iron pipe having a coefficient "C" = 130.

(b) 150 per cent of the capacity of an unlined cast iron pipe in average condition of tuberculation "C" = 100, and

(c) 187 per cent of the capacity of an unlined cast iron pipe in badly tuberculated condition "C" = 80.

Increase in Cost

With bid prices received at Newton, Mass., in August, 1932, the cost of lined pipe delivered exceeded the cost of unlined pipe delivered (based on average prices of 6 to 16 in. pipe) by the amount of 15 per cent. The additional cost of lining, when based on the total cost of the pipe line laid in the ground, will naturally be substantially less. Based on the cost of construction of a distribution system 22.9 miles in length in Parsippany, N. J., in 1931, the cost of the lining amounted to but 5.6 per cent of the total cost of the pipe in place.

El Paso, Texas, Looks Ahead

The city of El Paso, Tex., has taken advantage of the low price of copper and its water works department is replacing its corroded service pipes with copper. Approximately 5,500 services, or a third of the total of 16,000 have been replaced up to this time. The department recently purchased 40,000 ft. of copper pipe at prevailing low prices for these replacements and it is expected that this will be enough for two years' supply.

A. H. Woods, Superintendent of the El Paso Water Department, reports that his experience has shown that rustable service pipes will last only from 2 to 15 years, depending upon the type of soil in which they are laid. From his observations, during recent years of experience with copper services, he predicts that there need be no replacements of these for a great number of years.

The superintendents of water works in numerous other cities have had the same experience as Mr. Woods, appreciating that unless the proper metal is used the service pipe suffers attack from one if not both sides at once. The water attacks it from the inside and soil corrosion in numerous instances causes attack from the outside.

The use of service pipe, not resistant to corrosion, has caused much complaint on the part of the householder. Low pressure and discoloration of plumbing fixtures and clothing are the two most prevalent complaints. Further, when replacements are necessary it is frequently necessary to tear up and generally mutilate lawns and walks.

The trend toward the use of copper water services by water works departments in progressive cities has been marked in the last few years. Water works departments in numerous cities have taken the view that replacements at this time are highly desirable. The present low price of copper is being taken advantage of and at present replacement work affords an opportunity to give employment to those of their communities who are without work.

TREATMENT PLANT AT PRINCETON, UNIFIES SEWAGE DISPOSAL

By TRUMAN M. CURRY, JR.

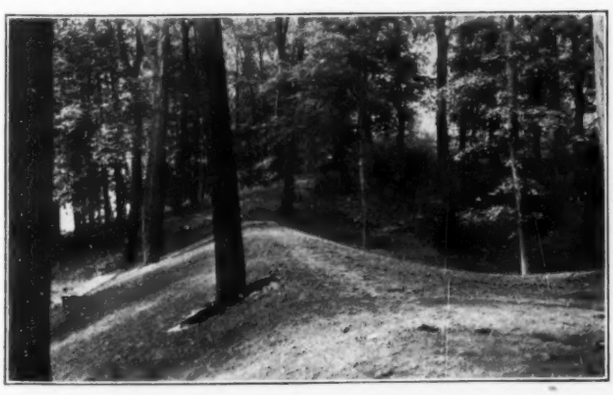
Associate Engineer with Nicholas S. Hill, Jr., Consulting Engineer.

THE new trunk sewer, pumping station, and sewage treatment plant for the Borough, Town and University of Princeton are now in service after a construction period of slightly more than a year. Financing and construction were undertaken by the Borough, acting for itself and on behalf of the Town and University. Fixed charges and operating costs are to be reapportioned every third year among the three parties on the basis of relative water consumption.

Princeton Township, within which the Borough and University are located, is situated in Mercer County, N. J., largely on ground rising from the Millstone River on the east, from its tributary, Stony Brook, on the south and west, and from another branch, Harry's Brook, on the north. A low dam across the Millstone River two miles northeast of the center of Princeton Borough impounds a long, shallow body of water east of Princeton known as Carnegie or Princeton Lake. Practically all sewage from within the Township, until diverted by the new trunk sewer, reached this lake directly or through Stony Brook and Harry's Brook. The sewage before reaching the lake or tributary streams underwent differing degrees of treatment in separate small plants which had for the most part become overloaded or outworn. Two of these plants received sewage from the Borough of Princeton, another from the University, and several others, privately owned, from schools and real estate developments located within the Township.

In order to achieve the benefits of consolidated treatment and control, and to eliminate undesirable conditions in the streams and offensive odors emanating from some of the existing plants, it was decided to convey the sewage from the various localities through a trunk sewer and several branches to one large new plant of modern design and adequate capacity, and to abandon all the old plants.

The selection of a treatment plant site suitable in respect to the isolation desired and to the feasible and economic location of the trunk sewer was not readily made owing to the difficulties which it became evident would develop if land for the purpose were sought outside of the Township boundaries. The location finally chosen was one three miles northwest of the center of Princeton Borough in a wooded area on the west slope of the Millstone River valley, just within the township and county limits.



Typical Embankment Over Trunk Sewer at Gulley Crossing.

Head House Containing Chlorinators, Sludge Pump Laboratory and Office

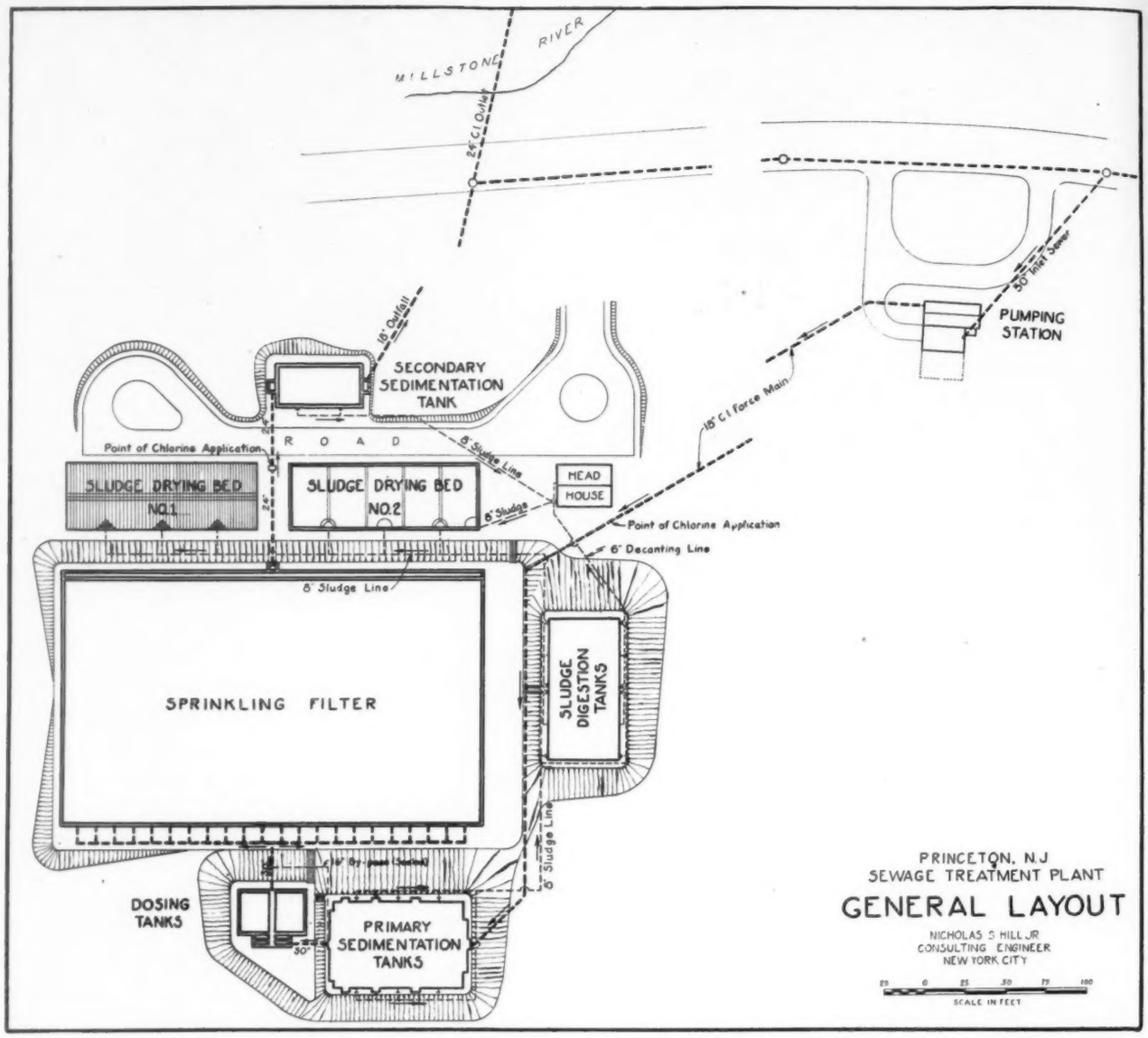
Protection of Scenic Beauty

In the design of the new sewage treatment plant attractiveness of appearance was given careful attention, to suit the natural beauty of the selected site overlooking the Millstone River valley. Upon completion of the plant construction, its surroundings were landscaped and the locality now forms a park area worthy of remark.

Care was taken to maintain in every particular the well-known beauty of Princeton's outskirts through which the trunk sewer had to pass. Many small trees were saved by transplanting and the sewer line located so as to avoid destruction of larger ones. Where it became necessary to construct the trunk sewer in embankment, as at gulley crossings, particular attention was given to achieving effects harmonizing with the surrounding terrain. Rubble stone masonry was used in some instances in place of concrete for the culvert headwalls, and new embankments were made to blend with the original ground surfaces by varying their slopes wherever possible.

Trunk Sewer

From its downstream end at the new treatment plant the trunk sewer extends southward along the west bank of the Millstone River and Carnegie Lake, and then swings west and north in a broad semicircle along the north and east bank of Stony Brook. Considerable portions of the line pass through exceptionally rough terrain. A branch of the trunk sewer extends westerly and southwesterly along Harry's Brook north of Princeton, nearly closing the circle of new sewers which now envelop the Borough and University and a major portion of the township area. These sewer lines not only serve their primary function of transporting the sewage from the various sewered areas within the township limits downstream to the new treatment plant, but also provide means for disposal from other partially developed areas where sewerage is likely to be installed in the not remote future. The trunk sewer at its lowest end will carry 9 million gallons per day of sewage when flowing filled to three-quarters of its depth, or sufficient for the peak flows likely to occur with a future population of about 25,800. At present the sewer serves about



General Layout of Sewage Treatment Plant of Princeton, N. J.

11,000 persons, including the University part-year population.

The new branch and trunk sewers are thirteen miles in length, and were built under two concurrent contracts of approximately equal size, awarded on Oct. 14, 1931, and completed within the contract time of one year. Approximate lengths of the various sizes of sewer laid are:

36 in.	3,700 ft.
30 in.	9,000 ft.
24 in.	28,200 ft.
18 in.	11,700 ft.
15 in.	2,200 ft.
12 in.	3,300 ft.
10 in.	10,500 ft.
Total	68,600 ft.

Sewer lines 24 in. and larger are built of reinforced concrete pipe with mortar filled joints, and sewers 18 in. and smaller of vitrified pipe having joints filled with bituminous compound. Manholes are of brick masonry. The concrete pipe was purchased by the Borough and delivered by the manufacturer to the contractors. Infiltration into the 13 miles of new sewer is less than 65,000 gallons per day, of which a minor portion occurs in the 7¾ miles of concrete pipe line, laid generally in drier ground than the clay pipe line. An inverted syphon passing under Harry's Brook on the 36-in. trunk sewer line and 1,176 ft. in length consists of one 16 in., one 20 in. and one 24 in. parallel cast iron pipe lines to provide self cleaning velocities at the various rates of sewage flow likely to occur. A smaller two-pipe inverted syphon crosses beneath a stream gulley on the 24 in. sewer line.

The Sewer Committee at Princeton, aided by wide community interest in the project, has to its credit the achievement of obtaining without cost the very numerous and often extensive rights-of-way through private properties required for the economic location of the trunk sewer.

Pumping Station

The trunk sewer effects conveyance of the collected sewage by gravity to a point beside the county highway on the west bank of the Millstone River 2,000 ft. from the new treatment works. At this point a pumping station has been erected and equipped with pumps which lift the sewage through an 18 in. cast iron force main to the higher elevation of the treatment plant.

The pumping station is equipped with one 1 M.G.D.,

one 2 M.G.D., and one 4.5 M.G.D. Fairbanks-Morse electrically driven vertical sewage pumps, which automatically go into operation in any desired sequence under float-switch control as the sewage rises in the suction well. Combined static and dynamic lift is about 77 ft. A standby Buffalo gasoline engine driven generator is installed to furnish electric power in case of failure of the regular purchased supply. Inlet to the suction well

Sewage Pumping Station, Princeton, N. J.

is equipped with a ½ in. by 3 in. inclined bar screen having 1 in. openings. The screen is of large area, 15 ft. in length by 4 ft. in effective depth, and is backed up by a concrete baffle weir to maintain full submergence of the screen at all times in the incoming sewage. The pumps are located in a dry well. Both the suction well and the dry well are easily accessible by stairways. The quantity of sewage pumped into the force main is measured by a recording venturi meter.

Treatment Plant

The treatment provided at the new Princeton works consists of sedimentation with separate sludge digestion, oxidation by biological action in a trickling filter, and sterilization with chlorine. The plant as now built is designed for an average flow of 2 M.G.D. and a maximum rate of 6 M.G.D., sufficient to serve a future population of about 17,500. At present the average flow reaching the plant is about 1.35 M.G.D. Provision is made for future enlargement as required, by the construction of additional units so that a population of about 25,800 may ultimately be served, which is the same as that for which the new trunk sewer was designed and built. This population is about twice the present population in the Township, Borough and University, and will not, as far as can be foreseen, be attained before 1975.

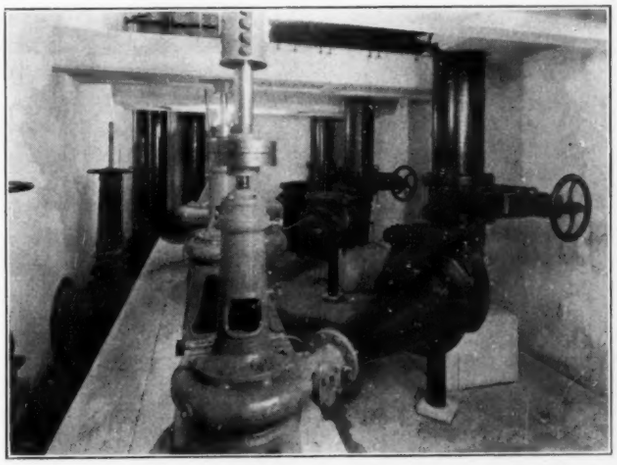
The sewage is delivered through the force main to the covered primary sedimentation tanks, which are built of reinforced concrete with the upper portions of the walls concealed within grassed and planted embankments. The tanks are in two parallel units, each having three 45 degree pyramidal hopper bottoms. Sewage can be passed through either one or both of the settling units simultaneously depending on the quantity of sewage being handled and the time of detention desired. Allowing space for sludge storage, the detention period when using both units for a 20 M.G.D. flow is four hours. Reinforced concrete baffles prevent short circuiting. A sludge draw-off pipe of 8 in. cast iron extends downward to a sump at bottom of each hopper, and by opening a gate valve deposited sludge in the hopper is drawn off to the sludge digestion tanks under action of the pressure of super-imposed sewage in the settling tanks without interrupting the sedimentation process. Scum chambers are provided at the sides of the settling tanks to facilitate skimming operations.

The sludge digestion tanks are of reinforced concrete with upper portions of the exterior walls concealed in embankment. The digestion tanks, of 3 cu. ft. per capita capacity, are built in two units each having four sections with hopper bottoms. The four sections are interconnected by 8 in. piping and valves which permit circulation of the sludge, as digestion progresses, through the compartments in any desired order when differences in the various sludge levels are established. This arrangement facilitates stage digestion. Sludge in the tanks may be agitated by water introduced through perforated lead pipes laid around the inner surfaces of the hoppers. Supernatant sludge liquor is decanted from any chamber by gravity to a suction well in the operating house where an automatically operated pump forces it, as desired, either into the raw sewage force main, into the dosing tanks or onto one of the sludge drying beds. Drawing off the liquor is thus accomplished gradually and without disturbing the sludge. Provision is made for withdrawing ripened sludge from the digestion tanks at three different levels. The use of stirring mechanisms is not required.

The cover slab is designed for future collection of gas whenever such collection becomes warranted economically. Generous capacity of the tanks at present renders artificial sludge heating unnecessary.

The settled sewage from the primary sedimentation tanks flows through a ¼ in. bronze mesh screen into twin dosing tanks of reinforced concrete provided with Pacific Flush Tank dosing fixtures. The twin tanks alternately apply sewage to the trickling filter nozzles, and with the distribution piping as designed provide uniform spray dosing over the entire filter bed. High water level in the dosing tanks is 9 feet above the level of the spray nozzle orifices.

Horizontal dimensions of the concrete trickling filter basin are 151 × 260 ft., forming an area of 0.9 acre. Two inch crushed trap rock 8 ft. deep is used as the filter medium, providing a rate of treatment of some-



Pump Well and Automatically Operated Sewage Pump.

what less than 300,000 gallons per day per acre per foot of depth.

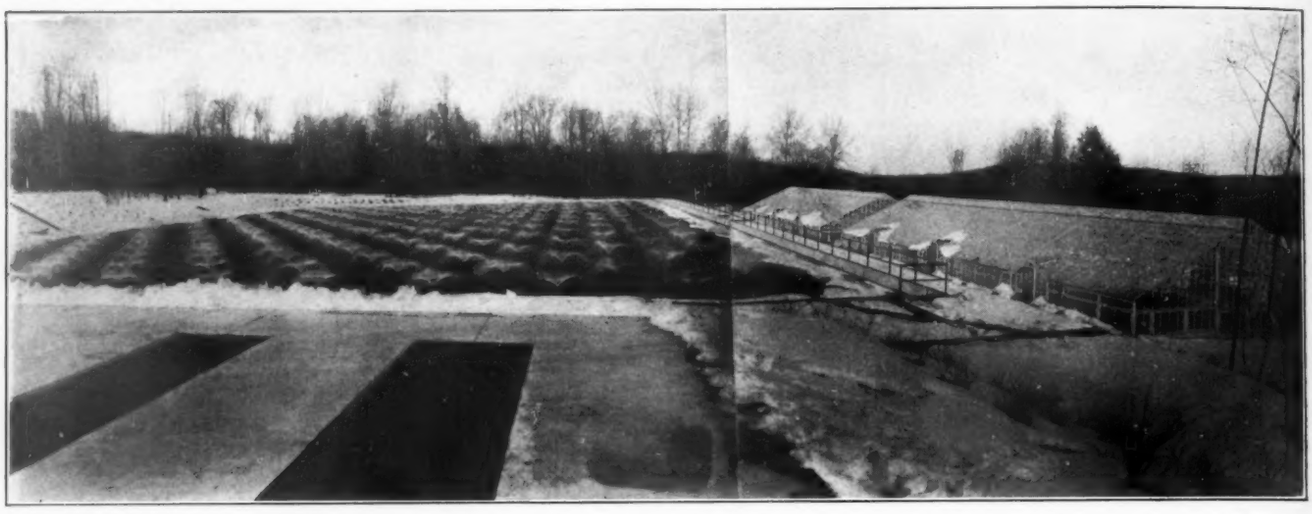
Distribution piping in the filter is of Universal cast iron pipe, laid in parallel lines 11 ft. 6 in. on centers just below the top surface of and supported by the filter stone. Should the necessity arise this piping may be quickly dismantled or the end plugs removed for cleaning. Each line is equipped with Pacific Type D sewage spray nozzles staggered 13 ft. on centers. Valves

on all laterals permit the shutting off of any section of the bed. Flooding of the bed can be effected to eliminate flies by closing an effluent gate.

The under drain system consists of 12 in. half-round vitrified clay split pipe laid in lines 20 in. on centers upon the concrete floor of the filter basin. These drain to an effluent channel which in turn discharges through a 24 in. reinforced concrete pipe to the secondary sedimentation tank.

The secondary sedimentation tank is an open reinforced concrete basin with two hopper bottoms similar to those of the primary tanks. Detention period at a 2 M.G.D. rate is one hour, during which time matter carried over from the trickling filter when unloading has opportunity to settle out. Sludge is removed through cast iron pipes from the bottom of the hoppers when a small pump is operated in the control house. This is by Hitchings & Company, have continuous ventilating sash at the ridges opening outward and at the sides opening inward. Masonry sills are kept low to reduce the extent of shadows on the drying sludge.

The contract for constructing the treatment plant was awarded in October, 1931, at the same time as the trunk sewer contracts. The plant was completed and placed in continuous operation in December, 1932. While it is too early to discuss fully the results obtained in operation it may be stated at this time that high nitrification is being achieved, the trickling filter effluent showing 12 to 15 p.p.m. nitrates. Pre-chlorination at a rate of 3 to 5 p.p.m. is successfully eliminating odors. With summer weather, heavier pre-chlorination will probably be required. Final chlorination, using 2 to 3 p.p.m., is rendering approximate sterilization. Relative stability of the plant effluent is consistently 90 per cent plus.



Trickling Filter and Sludge Drying Beds from Roof of Digestion Tanks at Sewage Treatment Works, Princeton, N. J.

the same pump used to force decanted liquid from the digestion tanks back into the sewage stream.

At the entrance to the secondary settling tank the sewage effluent is continuously chlorinated by a Wallace & Tiernan solution feed chlorinator located in the control house, the secondary tank providing time for contact between the chlorine and treated sewage prior to discharge of the latter through an outfall sewer extending 1,800 ft. to a multiple submerged outlet in the Millstone River.

A semi-automatic Wallace & Tiernan solution feed chlorinator is also provided for pre-chlorination of the sewage in the force main as it arrives at the plant from the pumping station. Its intermittent operation is based upon that of the main sewage pumps, being controlled by their float switches. Water for the chlorinators is drawn from the effluent in the secondary sedimentation tanks.

The head house or control house at the treatment plant is of brick with slate roof similar architecturally to the pumping station building. Within it are contained a well equipped laboratory, office, chlorinator room, small pump room, heater room and store room.

The sludge drying beds are in two glass-covered units each approximately 40 × 118 ft., providing 0.5 sq. ft. of area per capita for a population of 17,500 persons. Each unit is divided into five beds, made up of a 6 in. layer of sand on an 8 in. layer of graded crushed stone. Underdrainage consists of 4 in. vitrified pipe lines with open joints draining to the main sewage effluent line at the chlorinating manhole. The glass covers, furnished

Nicholas S. Hill, Jr., Consulting Engineer, New York City, prepared the plans and specifications for the treatment plant and sewers and had general supervision of construction. I. Russell Riker was Resident Engineer for the Borough of Princeton during construction and is now Sanitary Engineer in charge of operation. Contractors were Engstrom & Wynn, Inc., of Wheeling, W. Va., for construction of the treatment plant, and Vincenzo Di Francesco, Llanerch, Pa., and Cestone Bros., Inc., Montclair, N. J., for the two trunk sewer contracts. Lock Joint Pipe Co., Ampere, N. J., manufactured the reinforced concrete pipe.

Cost

The cost of the new sewerage work at Princeton may be summarized as follows:

Treatment Plant, Pumping Station and 6,000 ft. of 6 in. cast iron water main	$237,600
Trunk and branch sewer construction (13 miles)	255,000
Reinforced concrete sewer pipe purchased by Princeton	53,900
Total	$546,500

▼

Four States Section to Meet at Cherry Blossom Time.—Word from Charlie Becker, Secretary of the Four States Section of the A. W. W. A., states that the meeting of this Section is to be held in Washington, D. C., April 27th and 28th during the period when the famous cherry blossoms will be in full bloom. That sight alone should be worth the trip to Washington.

LARGE SCALE SLUDGE DIGESTION EXPERIMENTS AT BALTIMORE

By C. E. KEEFER

Principal Assistant Engineer,
Bureau of Sewers, Baltimore, Md.

IN an endeavor to collect additional data relating to the operation of heated separate sludge digestion tanks, two of the existing tanks at the Baltimore sewage works were altered so that the tank contents could be heated and the gas collected and used. The first tank to be remodeled is, so far as the writer knows, the only one of its kind in the United States. The unique feature of it is that cold water, taken from the water mains, is heated and added direct to the sludge for heating purposes. This method of heating sludge tanks, which has been advocated by Imhoff, has been used for a number of years at Essen-Rellinghausen[1, 2], Germany, and has recently been adopted on a larger scale for heating the new sludge tanks[3] at that sewage works.

The second heated sludge tank to be put in service at the Baltimore sewage works is similar to most of those in this country, where hot water is circulated through pipe coils in the tank. The results obtained indicate that less total heat is required where hot water is circulated through pipe coils than where the water is added direct to the tank. Furthermore, this type of tank produced considerably more gas per unit volume of fresh volatile matter. On the other hand the sludge in the tank, to which the heating water was added direct, was considerably more concentrated.

Tank 10 Heated by Adding Hot Water Direct to Sludge

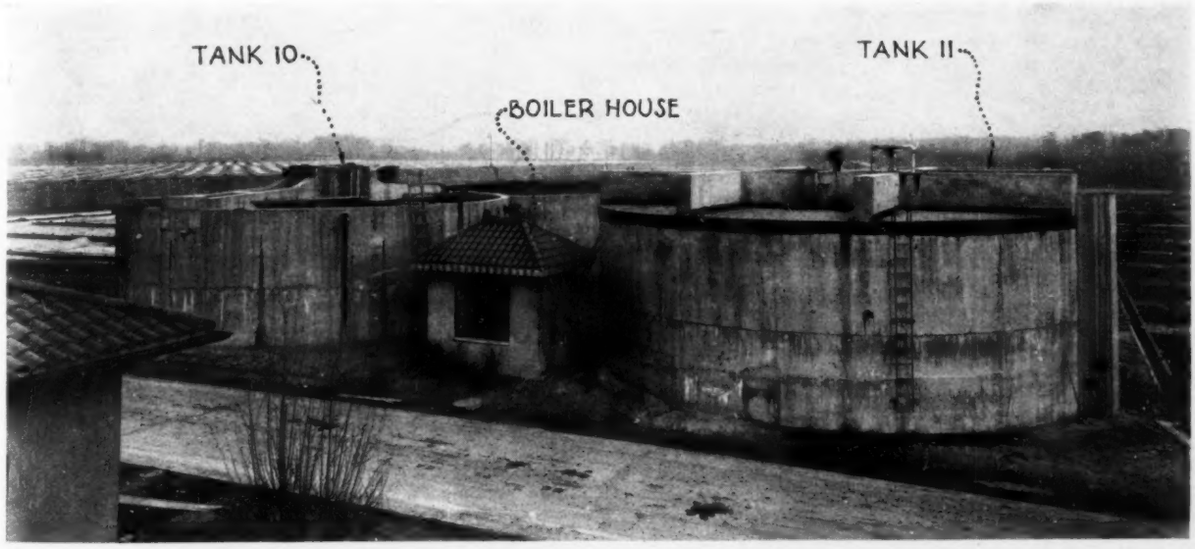
The collecting of data on the operation of heated sludge tanks at Baltimore was begun in 1929 when Tank 10, which was one of the existing tanks at the sewage works, was remodeled so that it could be heated and the gas from the digesting sludge collected and used. This tank, which has a working capacity of 19,500 cu. ft. when full, has, as indicated in Fig. 1, an internal diameter of 38 ft. and a depth of 15 ft. at the side walls. The bottom of the tank has the shape of an inverted cone with a depth at the center of 24½ ft. The top of the tank and upper 12 ft. of the side walls, which are of concrete 12 in. thick, are exposed to the atmosphere, and are uninsulated.

The remodeling of the tank consisted of covering the top with a submerged concrete roof 3 in. thick. This roof slopes upward toward the center, where there is a gas vent 7 ft. by 2½ ft. in plan, equipped with a sheet metal hood. Between the inner face of the tank wall and the outer edge of the roof there is an annular space 1 in. wide, which is about 1 ft. below the tank overflow and serves as a passageway for the flow of sludge liquor. A gas boiler was installed to generate steam, which in turn heats the water flowing through an instantaneous heater to the sludge tank.

Raw sludge enters the tank at the side, and is drawn off hydrostatically near the bottom through an 8-in pipe. This tank is heated by adding the hot water direct to the sludge through two 1½ in. pipes, which terminate 1½ ft. above the tank bottom. As the hot water enters the tank, an equal quantity of displaced sludge liquor discharges out through four 4-in. overflow pipes.

Some of the claims made for this type of tank[4] are that a better transfer of heat is possible by a direct mixing of the hot water with sludge than where heat has to pass from a pipe coil in the tank to the sludge. Furthermore, the first cost is less as it is not necessary to install these coils. It is also feared that after a period of time pipe coils may become incrusted with sludge with a retardation in the transfer of heat.

The gas given off by the digesting sludge flows through a 1½ in. pipe to a gas meter, a flame trap, a pressure relief trap and then to the gas boiler with a rated capacity of 170,000 B.t.u. per hour. Excess gas passes from the pressure relief trap to the atmosphere. In order to facilitate the operation of the equipment a gas holder with a capacity of 15,100 cu. ft. has recently been installed at a cost of $4,798. Instead of constructing a tank for hold-



Back River Sewage Treatment Works. Sludge Digestion Tanks Nos. 10 *and* 11 *Heated with Hot Water.*

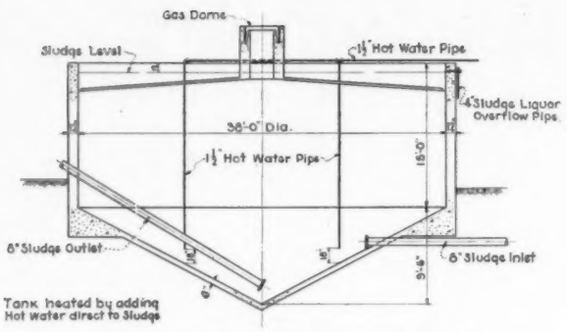


Fig. 1—Section of Sludge Tank No. 10

ing the gasometer, one of the existing circular sludge tanks was utilized at a considerable saving.

Operating Results—Sludge Tank 10 was put in service on Oct. 30, 1929, when it was filled with partially digested sludge. The first digested material was withdrawn on Nov. 5, 1929, and from then on through 1930 either digested sludge or sludge liquor was removed every 6 or 7 days at the rate of 390 cu. ft. daily, which volume equals 2 per cent of the tank contents. The tank was then immediately refilled with undigested material. The raw sludge was obtained from the preliminary settling tanks, and was usually about 5 or 6 days old with a pH value as low as 4.9 to 5.0 and a volatile content averaging 75.4 per cent. Although it would have been desirable to add the undigested sludge in small daily increments, this procedure was not practicable as it would have greatly increased the operating difficulties at the sewage works.

During the first part of the experiment it was the practice to withdraw digested sludge prior to the addition of raw material. This method of operating the tank, however, tended to deplete it of sludge as the concentration of solids in the digested material was always greater than that of the raw sludge. The investigation had not progressed very far when it became evident that it was desirable to keep as large a quantity of solids in the tank as possible with a correspondingly small quantity of supernatant sludge liquor. Valves had been provided on the side of the tank, one above the other, for the removal of this liquor. Before removing digested sludge, the uppermost valve on the side of the tank was opened, and in case there was any sludge liquor at this level it was run off.

The operating results for 1930 are given in Table I and Figs. 2 and 3. During the year 148,400 cu. ft. of raw sludge with an average moisture content of 94.6 per cent and containing 8,010 cu. ft. of dry solids were added. The digested sludge withdrawn amounted to 17,260 cu. ft. with a moisture content of 92.2 per cent, containing 1,350 cu. ft. of dry solids. There was also a withdrawal of 131,140 cu. ft. of sludge liquor, which contained 99.3 per cent moisture and 905 cu. ft. of dry solids. The tank is estimated to serve 11,870 persons with a capacity of 1.64 cu. ft. per person.

The gas production amounted to 0.43 cu. ft. per capita per day or 5.02 cu. ft. per pound of fresh dry volatile solids added. The average monthly temperatures varied from a minimum of 62° F. in February to a maximum of 86° F. in September. The average temperature in the tank for the year was 73.5° F. A total of 42,900 B.t.u. per hour was added to the heating water, which consisted of 11,500 B.t.u. per hour for raising the temperature of the cold water up to the temperature of the sludge in the tank and an additional 31,400 B.t.u. per hr. to bring the temperature up to 137.8° F., the temperature of the hot water entering the tank. The quantity of heating water added to the sludge averaged 58.8 gal. per hr., or 0.12 gal. per day per capita served, which volume equals 0.15 per cent of the sewage flow per capita daily. It is of interest to note that if the tank design had been such that displaced sludge liquor had flowed from the tank as raw sludge was introduced, as is frequently the case, the volume of this liquor would have amounted to 128 gal. per hour, or 117 per cent more than the volume of sludge liquor discharge due to the addition of hot water.

With an average daily gas production of 5,127 cu. ft., having an estimated heating value of 700 B.t.u. per cu. ft., an average of 150,000 B.t.u. per hour were available for heating purposes. Although the volume of gas burned was not measured, it is estimated that its heat

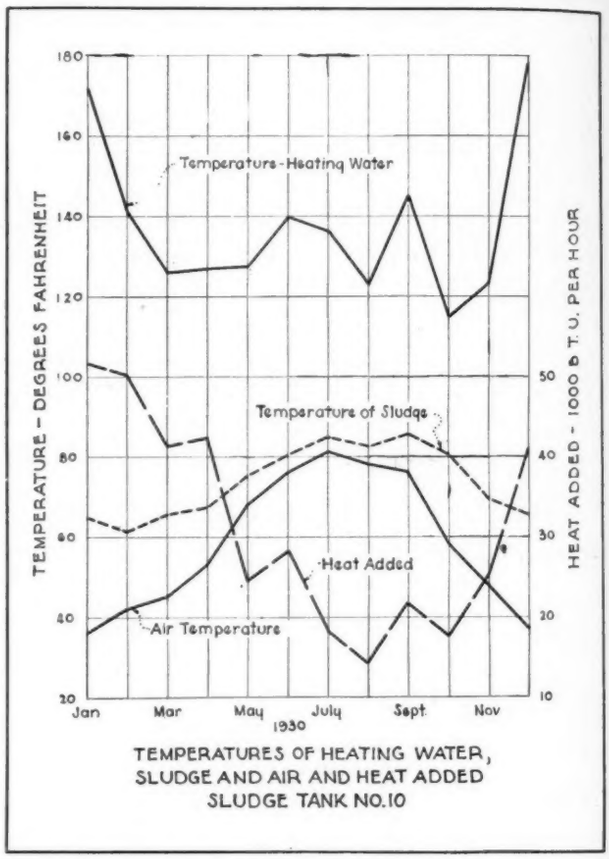


Fig. 2—Temperatures of Heating Water, Sludge and Air and Heat Added Sludge Tank No. 10

TABLE I.—1930 RESULTS FROM TANK 10 HEATED WITH HOT WATER ADDED DIRECT TO TANK

	Wet			Dry
	Quantity, cu. ft.	Volatile matter, per cent.	Moisture, per cent.	Solids, cu. ft.
Raw sludge added	148,400	75.4	94.6	8,010
Digested sludge withdrawn.	17,260	54.4	92.2	1,350
Sludge liquor withdrawn	131,140	....	99.3	905
Volume of sludge liquor overflow			58.8 gals.	per hr.
Estimated number of persons served			11,870	
Estimtaed tank capacity per person			1.64 cu. ft.	
Gas production:				
Total for year			1,871,400 cu. ft.	
Daily average			5,127 cu. ft.	
Daily average per capita served			0.43 cu. ft.	
Per pound of fresh volatile solids			5.02 cu. ft.	
Quantity of hot water added:				
Average			58.8 gals.	per hr.
Maximum			169.5 gals.	per hr.
Minimum			8.5 gals.	per hr.

value was about 61,000 B.t.u. per hr. About 41 per cent of the gas, therefore, was used for heating.

Tank 11 Heated with Hot Water Coils

During the summer of 1930 Tank 11, another of the circular sludge tanks at the sewage works was remodeled. This tank is the same size and shape as Tank 10. Around the inside walls of the tank were hung five, standard, genuine wrought iron pipe coils. The pipe, which was galvanized, was 2-in. in diameter and 0.154-in. thick. As there is little data on the heat transfer through hot water pipe coils in sludge tanks, it was decided to design the piping so that from 1 to 5 coils could be put in service as desired. The five coils furnished a radiating surface of 381.7 sq. ft. This arrangement of piping made it possible to determine the heat transmitted to the sludge by various areas of radiating surfaces.

The tank was covered with a concrete roof 4½-in. thick. Especial attention was given to the design and construction of the roof in order to insure gas-tight construction. A high percentage of reinforcing steel was used to minimize the number of contraction joints. As an added precaution the under side of the roof and the

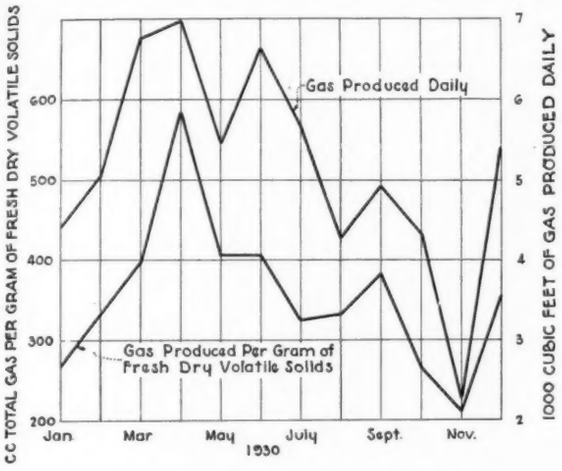


Fig. 3—Gas Production Sludge Tank No. 10

to portion of the inside walls of the tank for a distance of about 2 ft. below the concrete roof were thoroughly coated with a layer of asphalt mastic compound, which averaged from 1/16 to ⅛-in. in thickness.

The tank was provided with a trapped 4-in. overflow pipe. This pipe was placed so that there was a gas space of 12 ins. between the tank roof and the sludge. Provision was made for getting temperatures by means of a recording thermometer at two points in the tank, the first 5½ ft. and the second 17 ft. below the roof. The upper thermometer is generally always in the sludge liquor zone, and the lower is in the sludge. It was believed that possibly the temperature of the sludge would be somewhat different from that of the sludge liquor. Downes,[5] for example, reports that at the Plainfield sewage works the sludge can be maintained at 72° F. with the supernatant liquor at 60 degrees. During the 15-month period that the tank has been in service in Baltimore, the average temperatures at the two points in the tank have been practically the same. There have been times, however, usually of short duration, when the temperature at one point was as much as 5 or 6° higher than the other.

The tank was put in operation on Aug. 1, 1930, by filling it with partially digested sludge. Within a short time considerable quantities of gas began to be produced. The concrete roof, which was believed to be gas tight, leaked to such an extent that there was insufficient pressure in the gas pipes to keep the gas boiler lit. It was hoped that the leaks could be stopped by coating the upper side of the roof with asphalt mastic. Although this remedy was tried, no success was had. As there had appeared to be no difficulty with the leakage of gas from sludge tanks, the roofs of which are submerged in sludge, it was decided to alter the design of the overflow pipe, and raise the sludge level so that the under side of the roof would be submerged. As soon as this change was made, the gas leaks stopped. Since then there has been periodically some little difficulty with the escape of gas, but each time the trouble has been corrected by pouring hot asphalt over the places where the leaks occurred.

TABLE II.—1931 RESULTS FROM TANK 11 HEATED WITH HOT WATER COILS

	Wet			Dry
	Quantity, cu. ft.	Volatile matter, per cent.	Moisture, per cent.	Solids, cu. ft.
Raw sludge added	139,250	78.7	94.8	7,240
Digested sludge withdrawn	21,250	56.5	93.2	1,450
Sludge liquor withdrawn	118,000	....	99.7	350
Estimated number of persons served			10,730	
Estimated tank capacity per person			1.92 cu. ft.	
Gas production:				
Total for year			2,219,100 cu. ft.	
Daily average			6,080 cu. ft.	
Daily average per capita served			0.57 cu. ft.	
Per pound of fresh volatile solids			6.24 cu. ft.	

Operating Results.—The raw sludge added to Tank 11 amounted to 139,250 cu. ft., containing 94.8 per cent water and 7,240 cu. ft. of dry solids. The digested sludge withdrawn totaled 21,250 cu. ft. with a moisture of 93.2 per cent. The dry solids amounted to 1,450 cu. ft. A total of 118,000 cu. ft. of sludge liquor was withdrawn, containing 99.7 per cent water and 350 cu. ft. of dry solids.

The raw sludge pumped into this tank was similar in character to that put in Tank 10. Throughout the year the sludge was added every 6 or 7 days. The practice of withdrawing sludge liquor in preference to digested sludge was followed in operating this tank the same as with Tank 10. The operating results are summarized in Table II and Fig. 4 and 5. The gas production amounted to 0.57 cu. ft. per capita per day of 6.24 cu. ft. per pound of fresh dry volatile solids. It is estimated that the tank served 10,730 persons with a capacity of 1.92 cu. ft. per person. The average yearly temperature of the heating water entering the pipe coils in the tank was 123° F., of the return cold water 84° F. and the sludge 80° F. The heating water pumped amounted to 210 gal. per hour, and flowed with a velocity of 0.3 ft. per second through the heating pipe. The heat added to the sludge averaged 67,500 B.t.u. per hour. The average amount of heat available from the gas produced was approximately 177,000 B.t.u. per hour, and the estimated heat value of the gas used for heating was 96,000 B.t.u. per hour. About 54 per cent of the total gas production was used for heating, and the remainder was wasted.

Heat Transfer Through the Pipe Coils.—There is little printed data on the heat transfer through pipe coils used to heat sludge tanks. The engineer, who is faced with the problem of designing heating coils of the proper size and length has little information that will help him in his designs. With the hope that some data could be obtained regarding this subject, the temperatures of the heating water and the sludge in Tank 11 were obtained over a considerable period of time.

The resistance to the passage of heat from hot water flowing in a pipe to sludge is made up of three factors. The first is the resistance to the transfer of heat by the relatively stationary film of water on the inside of pipe

adjacent to the pipe walls. This value depends upon a number of variables including the inside diameter of the pipe, the velocity of the water, and the fluidity of the liquid film. The second resistance, which is relatively small if the pipe is clean, is that produced by the pipe wall itself together with the incrustation on the inside and the outside of the pipe. The third resistance is due to the film of liquid on the outside of the pipe, and varies with the viscosity of the sludge liquor or sludge and the rate of circulation around the pipe coils.

In the study of heat transfer similar to the above it is desirable where possible to determine the coefficient of

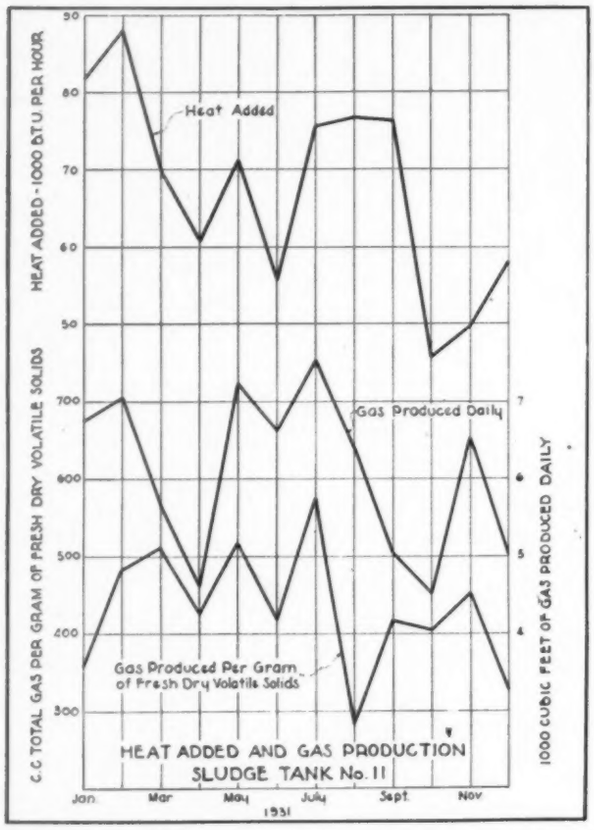

HEAT ADDED - 1000 BT U PER HOUR
C.C TOTAL GAS PER GRAM OF FRESH DRY VOLATILE SOLIDS
1000 CUBIC FEET OF GAS PRODUCED DAILY
Heat Added
Gas Produced Daily
Gas Produced Per Gram of Fresh Dry Volatile Solids
HEAT ADDED AND GAS PRODUCTION
SLUDGE TANK No. 11
Jan. Mar. May July Sept. Nov.
1931

Fig. 4—Heat Added and Gas Production Sludge Tank No. 11

heat transfer of each of the three above-mentioned resistances. In the present case, however, this procedure was impossible. The overall coefficient of heat transfer was calculated, therefore, with the thought that it would be of some value to the designer. This value averaged 10.7 B.t.u. per hour per square foot of pipe surfaces per degree (Fahr.) temperature difference. It is interesting to note that the transfer of heat through the copper pipe coils in the sludge tank at Halle, Germany, as reported by Heilmann and Müller[6] was 10.2 B.t.u. per hour per square foot per degree temperature difference.

Character of Sludge in Tanks.—Although a large number of separate sludge digestion tanks have been built and put in operation during the past few years, little is known regarding the moisture and volatile content of sludge at various depths in digestion tanks. This information is especially valuable to the designing engineer as it is desirable to know the average moisture to be expected in the sludge in order to determine the quantity of solids present and to calculate the proper digestion volume to provide. A tank designed to handle a definite quantity of solids with 94 per cent moisture would have to be 33 per cent larger than one required to digest the same material with 92 per cent water. Another important fact, regarding which information is needed, relates to the tank volume occupied by sludge liquor and scum.

A large number of analyses were made of the contents of both tanks. Of these, ten groups have been selected as being typical of conditions at different times in Tanks 10 and 11 (see Tables III and IV). The moisture of the sludge in Tank 10 was slightly less than in Tank 11. This condition is contrary to what might be expected especially as hot water was being added continuously to Tank 10. The average moisture of the digested sludge drawn from Tank 10 was 92.2 per cent and that from Tank 11 was 93.2 per cent. The sludge removed from Tank 10 contained about 15 per cent more dry solids than the material drawn from Tank 11. No satisfactory reason can be given for this difference. Perhaps the slow but continuous flow of hot water up through the digested sludge at the bottom of the tank tended to wash out the colloidal and other finely divided matter, leaving the coarser inorganic material with its lower moisture content behind. The solids below the sludge liquor consisted generally of digested material at the bottom with semi-digested or raw material at the top.

With reference to the formation of scum on the two tanks there was only a small amount of this material on

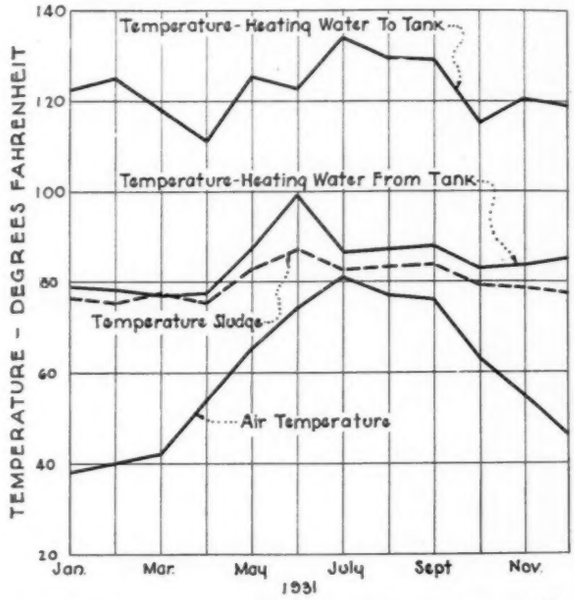


Fig. 5—Temperatures of Heating Water, Sludge and Air Sludge Tank No. 11

Tank 10, whereas the scum on Tank 11 was at times as thick as 6 ft., and was never entirely absent. The scum was always raw or semi-digested sludge, generally with a moisture content well below 90 per cent. The moisture of the scum collected from Tank 11 on Feb. 24, 1932 (See Table IV) was 79.4 per cent. The material was so dry that it would not flow into the sampling bottle. This condition, which is typical, exists even though the scum is submerged.

With regard to the sludge liquor in the two tanks the quantity depended entirely upon the way the tanks were operated. During a portion of 1930, when Tank 10 was in operation, no attempt was made to withdraw water in preference to digested sludge. The desirability of having as large a volume of solids as possible in the tank eventually became apparent. During the latter part of 1930 Tank 10 and during 1931 Tank 11 were operated so that there was very little sludge liquor present. As indicated by the tests made on March 27 and Nov. 20, 1931, there was no sludge liquor in Tank 11.

Comparison of Results.—Considerably more heat was

TABLE III.—CHARACTER OF SLUDGE IN TANK 10

Depth from top of tank, ft.	Mar. 19, 1930		Mar. 27, 1930		Apr. 3, 1930		May 26, 1930		Sept. 19, 1930	
	Moisture, pct.	Volatile matter, pct.	Moisture, pct.	Volatile matter, pct.	Moisture, pct.	Volatile matter, pct.	Moisture, pct.	Volatile matter, pct.	Moisture, pct.	Volatile matter, pct.
1..	....	....	....	....	....	....	....	....	....	....
2..	....	....	....	....	....	....	....	....	....	....
3..	99.1	74.0	99.5	67.0	99.5	69.1	99.6	59.3	95.5	72.6
4..	....	....	....	....	....	....	....	....	....	....
5..	99.2	71.9	99.3	60.9	99.6	69.5	99.7	57.7	97.6	72.1
6..	....	....	....	....	....	....	99.6	58.0	....	....
7..	99.0	71.0	97.8	58.1	99.7	57.5	....	....	96.2	67.8
8..	....	....	....	....	....	....	95.1	55.0	....	....
9..	98.0	59.5	97.2	56 6	95.2	56.2	....	....	96.7	62.8
10..	....	....	....	....	....	....	92.2	59.3	....	....
11..	94.5	60.9	96.0	55.5	93.8	54 3	....	....	95.3	64.1
12..	95.2	56.5	93.8	54.0	95.0	54.6	92.8	53.3	....	....
13..	94.6	60.5	93.0	54.7	94.4	54.7	93.1	53.1	94.2	56.5
14..	92.3	60.1	92.6	55.1	94.0	54.5	92.1	53.2	92.1	52.6
15..	92.0	55.6	91.8	55.7	91.9	54.1	91.2	53.0	92.0	52.2

TABLE IV.—CHARACTER OF SLUDGE IN TANK 11

Depth from top of tank, ft.	Nov. 18, 1930		Mar. 27, 1931		Nov. 20, 1931		Feb. 24, 1932		Mar. 14, 1932	
	Moisture, pct.	Volatile matter, pct.	Moisture, pct.	Volatile matter, pct.	Moisture, pct.	Volatile matter, pct.	Moisture, pct.	Volatile matter, pct.	Moisture, pct.	Volatile matter, pct.
1..	96.9	69.2	86 6	75.0	....	....	....	....	....	....
2..	99.4	67.2	84.6	75.6	....	....	79.4	72.1	81.6	70.8
3..	99.5	61.2	82.8	78.5	(Scum 6 ft.		(Scum 5 ft.		(Scum 3 ft.	
4..	99.6	63.9	98.7	70.7	thick)		thick)		thick)	
5..	99.7	54.2	97.7	70.0	....	....	....	....	98.9	69.6
6..	99.7	49.3	98.2	68.5	80.5	70.3	99.1	70.7	....	....
7..	99.7	58.4	97.7	69.8	94.5	62.1	....	....	97.7	69.3
8..	99.7	60.9	97.0	70.8	94.7	60 8	99.5	65.3	93.9	62.1
9..	99.7	53.3	97.5	70.3	95.1	58.3	94 4	57.3	93.8	61.3
10..	99.7	54.9	97.5	71.4	95.3	57.4	94.7	57.6	....	....
11..	99.7	56.6	97.0	66.9	93.4	66.8	....	....	93.7	61.3
12..	94.3	54.1	96.0	65.7	94.7	57.9	94.3	57.1	....	....
13..	94.5	54.0	95.5	71.7	94.2	58.9	94.5	57.2	94.5	59.6
14..	94.3	53.7	95.1	65.7	94.8	58.3	94.5	58.2	....	....
15..	94.2	54.3	95.4	66.7	94.9	56.5	....	....	94.2	58.9
16..	....	....	95.9	74.7	....	....	94.4	56.8	....	....
17..	....	....	93.9	64.6	95.0	58.8	94.2	55.5	94 8	57.9
18..	....	....	94.7	65.8	....	....	....	....	....	....
19..	....	....	94.2	68.9	....	....	....	....	94.4	57.5
20..	....	....	93.0	64.4	....	....	....	....	....	....
21..	....	....	94.2	66.7	....	....	....	....	....	....
24..	....	....	....	....	....	....	....	....	94.0	57.0

added to Tank 11 than to Tank 10. Some of the reasons were that Tank 11 was kept at an average temperature 6.5° F. higher than Tank 10, and the sludge added to Tank 11 was at a lower temperature than that put into Tank 10. The heat, which the pipe coils in Tank 11 failed to transmit to the sludge, was equal to the weight of the heating water times the temperature difference between the water in the pipe flowing from the tank and the sludge or 7,400 B.t.u. per hour. With reference to Tank 10 the heat, which was lost and from which no benefit was derived, was that needed to raise the temperature of the cold water up to the temperature of the sludge, and amounted to 11,500 B.t.u. per hour. If the same amount of heat had been added to Tank 10 as to Tank 11 with the heated water entering the former tank at 200° F., this heat loss would have been 15,100 B.t.u. per hour. It is apparent, therefore, that Tank 11 required less heat than Tank 10. On the other hand the heating of sludge tanks by adding hot water direct to the sludge has certain advantages. The cost of constructing a pipe coil in the tank and return piping to the heating plant is saved. As water at considerable pressure is generally available, it can be added direct to the tank without the use of additional pumps, whereas hot water, which flows through pipe coils in sludge tanks has to be pumped. One of the chief objections which might be made to adding hot water direct to the sludge would be that it would increase the moisture of the digested sludge withdrawn. The results of one year's observations indicate so far that the opposite is the case. Volume for volume, the sludge withdrawn from Tank 10 contained 15 per cent more solids than Tank 11.

About 10 per cent more solids were added to Tank 10 than to Tank 11. This difference is not significant as no attempt was made to operate the tanks at their maximum capacity in order to see which could digest the most sludge. It is believed that one tank can digest as much material as the other. Tank 11 produced 24 per cent more gas per pound of fresh dry volatile solids added than Tank 10. It is difficult to account for this marked difference in gas production. The only reason that can be given is that there is a continual flow of sludge liquor from Tank 10, containing solids, which possibly have not given off all their gas. The results obtained with both Tanks 10 and 11 were quite satisfactory. Although the means most widely adopted for heating sludge tanks in the United States is with pipe coils, there would seem to be no reason why satisfactory results should not be obtained by adding hot water direct to the sludge, and in some instances this type of tank might be more desirable to use.

The Baltimore sewage works is under the general supervision of B. L. Crozier, Chief Engineer, and George E. Finck, Sewerage Engineer, with G. K. Armeling, Superintendent.

BIBLIOGRAPHY

[1]Imhoff, Karl. "Utilization of Methane Gas from Imhoff Tank," *Eng. News-Record,* Vol. 91, p. 512.

[2]Imhoff, Karl. "Operating Results of the Essen Activated Sludge Plant," *Eng. News-Record,* Vol. 99, p. 790.

[3]Fries, F. "Die Kläranlage Essen-Rellinghausen un die Auswirkung ihrer letzten Erweiterung," *Gesundheits-Ingenieur,* Vol. 54, p. 661, 681.

[4]Sierp, F. "Specific Heat, Conduction and Generation of Heat during the Digestion of Sewage Sludge," *Sewage Works Journal,* Vol. 2, p. 191.

[5]Downes, J. R. "Gas Collection and Sludge Heating," *Sewage Works Journal,* Vol. 4, p. 72.

[6]Heilmann and Müller. "Über Bau and Betrieb der Nachfaulanlagen auf der Kläranlage Tafelwerder in Halle," *Gesundheits-Ingenieur,* Vol. 54, p. 161.

▼

Rockville Center to Have New Type of Sewage Treatment Plant

The village of Rockville Center, N. Y., has authorized the expenditure of $125,000 and let a contract for additions to the local sewage treatment works.

It is planned to filter the effluent from the existing activated sludge treatment plant by means of a Wright-mechanical filter which employs paper pulp as the filtering media and which is guaranteed by the manufacturers to produce an effluent containing not over 1 p.p.m. suspended solids. This filter will be the first of its type for the treatment of sewage in the manner prescribed.

The effluent will be allowed to flow on to the existing natural sand filters, pending a determination of its quality and the practicability of its discharge directly into the creek flowing through the village.

EVALUATION OF POWDERED ACTIVATED CARBON FOR WATER WORKS USE—A DISCUSSION

By MARTIN E. FLENTJE

Superintendent of Purification,
Community Water Service Co., New York City

THE evaluation of powdered activated carbons is of considerable importance to water works managers. A number of different carbons are available for purchase, but methods of evaluation have not been sufficiently studied and standardized. The following discussion of material from a number of sources is offered in the hope that it will stimulate further thought and investigative work.

It has been the experience of industrial users of activated carbon that evaluation has been practically impossible without correlation of laboratory tests and plant data. Activated carbons, for example, are notoriously selective, a property that may have an important bearing in the removal of tastes and odors from water. While powdered activated carbons now available have so far generally removed practically all tastes and odors in water supplies, a field report (Lexington, Ky.) and laboratory tests indicate they are practically valueless for adsorption of hydrogen sulfide gas from water. This may be an example of this property. On the other hand, later reports from several plants show removal of hydrogen sulfide gas where the carbon has been applied directly on top of the filters—and the case of Newport News, Va., with a dosage of 30 pounds per million gallons.

Other factors may also enter into the use and testing of carbons, among these being the hydrogen ion concentration, the effect adsorbable materials other than those it is desired to remove, the rate of the sorption reaction, and the physical character of the carbon itself.

The speed of adsorption may be important. It is known that temperature has an effect upon the rate of adsorption. A carbon of slow adsorption rate might be of little use in a purification plant where the carbon is applied to the filter influent, where the time of contact with the trouble-causing compounds must necessarily be very short. This property is probably very closely allied to the physical characteristics of a powdered carbon, such as for instance that of fineness or dispersibility. The attractive force of carbon particles in adsorption reactions has been shown to be small—probably of molecular dimensions. If this is true, we may assume that actual contact must be established between the carbon particle and the taste and odor producing particle before removal takes place. It is reasonable to expect that when comparing carbons of equal activity, but differing in the number of particles in a given weight, the one containing the larger number of particles per unit of volume will more effectively sweep out the troublesome substances and so remove a larger quantity. Extreme fineness alone might insure such contact of carbon and impurities under ordinary methods of testing, employing either violent shaking or prolonged stirring. In plant use, however, the number of particles remaining in suspension may also be of importance. In other words, the "suspendibility" of the carbon may have an important bearing on its efficacy. The term dispersion thus includes the two terms fineness and suspendibility. On the other hand there may be a practical limit to the fineness of carbon because of the danger of too highly dispersible carbon passing through an ordinary filter bed when applied to it in the manner in which carbons are used today.

Methods of Testing

The method generally followed for testing or evaluating activated carbons in the industrial field is, first, to make determinations the actual product to undergo treatment, out of which have developed several standard methods of evaluation that, however, are rarely interchangeable from one class of product to another; thus, again, confirming the selective character of the activated form of carbon. In cases where no standard test has been developed, recourse is made to actual test of the particular product—first, by laboratory test and subsequently by plant trial. With the variables in quality of the untreated product being more limited, the determinable factors as to dosages, etc., and their effect, are more easily ascertainable than has so far been proven to be the case in the treatment of water, some reasons for which are given later.

Direct Methods

One possible direct method would be to test the removal of some easily reproducible odor. The substance selected would have to be removed in the same ratio as the ordinary tastes and odors encountered. The introduction of the "Threshold Method of Odor Determination" by Spaulding has done a great deal towards making such a method possible. This method assigns a number to the intensity of an odor, which number is in reality the units of odor present in 100 ml. of the water being tested and is capable of more than fair reproduction and check. Its use should be considered seriously in acquiring the field data with which to compare any indirect methods of testing.

Unfortunately no easily reproducible odor seems to meet the demands of any direct test to evaluate carbons. Natural odors are not, of course, always available and tests with a number of odorous compounds from sauerkraut juice to oil of eucalyptus indicate little hope of success with such materials. However, confirmatory data of the action of carbon on natural substances in water can be obtained by the above mentioned method of odor determination.

Table I gives some results on the laboratory tests on five carbons of commercial grade, made with the hope of evaluating them for water purification use. The procedure followed was the addition of a standard carbon suspension in the dose of 0.5 p.p.m. to a 250 ml. sample of the water to be tested, the sample stirred rapidly, but not violently for exactly 3 minutes at a speed of 190 r.p.m. on a laboratory stirring machine such as is used

for coagulation tests. Filtering immediately thereafter the hot odor is determined by the Spaulding method. These carbons are all from one manufacturer.

TABLE I—NATURAL ODORS REMOVED BY CARBONS 1 TO 5

Odor	A Stagnant Odor of 80 % Removal	B Disagreeable pungent odor due to algae growth Odor of 66.7 % Removal	C Decided sweetish, grassy Odor due to algae. Odor of 166.7 % Removal
Carbon No. 1..	52.3	88.5	60
Carbon No. 2..	68.6	89.5	70.0
Carbon No. 3..	53.0	89.5	60.0
Carbon No. 4..	61.6	89.5	60.0
Carbon No. 5..	75.0	90.4	50.0
Carbon No. 6..	....	86.5	....

These results do no more than indicate the activity relationship between these carbons. It is significant, however, that in the three odors, Carbons No. 5 and No. 2 were either first or second in order of activity in 5 of the possible 6 cases. More tests similar to these might more definitely show this relationship.

Indirect Methods

Indirect methods offer certain advantages over present direct methods but they usually do not deal with substances found naturally in waters. Indirect methods, such as the phenol removal test, lend themselves to more convenient application of laboratory technique and are probably more accurate than any taste and odor determination method at present available. They allow the substitution of accurate chemical and color reactions for the methods that must deal with a certain personal element.

Any chemical compound that is adsorbed by activated carbon, and which can be accurately determined analytically, would do for use in an indirect method. Its usefulness to the water works man will in the final analysis be determined by how readily the results obtained through its use can be evaluated in terms of predictable removal of tastes and odors from water. Such data are not available at the present time and any indirect method must be used with an understanding as to its limitations.

Iodine Test

In judging the suitability of carbons for gas mask and other industrial uses, the iodine adsorption test is very commonly employed. A usual procedure is as follows:

> Add one gram of carbon to 50 ml. of a 0.20 N Iodine—Potassium Iodide solution. Shake exactly 3 minutes; filter, discarding first runnings; determine iodine content of an aliquot portion with a standard sodium thiosulfate solution using starch as an indicator.

This test was applied to the 5 carbons mentioned above, several other carbons and several samples of adsorbent clays.

TABLE II

Carbon	% Iodine Absorbed
No. 1	44.29
No. 2	68.01
No. 3	59.21
No. 4	39.35
No. 5	66.87
No. 6	48 89
An unactivated gas carbon	20.04
Fuller's Earth	7.60
Adsorbent Clay A	5.35
Adsorbent Clay B	4.47

One objection to this method is the high concentration of iodine and carbon employed. Smaller concentrations may be used, but this introduces difficulties of technique.

An attempt was made to modify the above method by determining the cc. of a standard carbon suspension required to remove 0.125 grams of iodine from a 50 ml. sample. These samples were shaken three minutes as before.

TABLE III

	ml. Carbon Suspension Required to Adsorb 0.125 Gms. I	Gms. Carbon Required
Carbon No. 1	12.50	.0625
Carbon No. 2	10.50	.0525
Carbon No. 3	11.75	.0587
Carbon No. 4	21.25	.0162
Carbon No. 5	11.00	.0550
Carbon No. 6	10.00	.0500
Unactivated gas carbon more than	50.0	.....
Bleaching Clay B over	200	.....

Phenol Test

The method of evaluation suggested by Baylis* has numerous advantages and some decided disadvantages. It approximates concentrations found in water supplies and treatment, uses a compound that can be determined accurately in small concentrations and is capable of reproduction. Its advantages lie in the amount of work involved, the skill required, and the extreme care and control that is necessary.

Phenol adsorption tests applied to the 5 carbons mentioned before are available and are given in Table IV.

TABLE IV

	P.P.M. Carbon Required to Reduce Phenol from 0.10 to 0.010 P.P.M. (Test suggested by Baylis.)
Carbon No. 1	37.0
Carbon No. 2	18.0
Carbon No. 3	33.0
Carbon No. 4	43.0
Carbon No. 5	33.0

Summarization

Table V summarizes results from all tests.

TABLE V—ACTIVITY OF CARBONS BY VARIOUS TESTS

With Respect to Order	Odor A No.	Odor B No.	Odor C No.	Standard I-Test No.	Modified I-Test No.	Phenol Adsorption No.
1	5	5	2	2	2	2
2	2	2–3–4	1–3–4	5	5	5–3
3	4	2–3–4	1–3–4	3	3	5–3
4	3	2–3–4	1–3–4	1	1	1
5	1	1	5	4	4	4

Modifications of the Phenol Test

Modification of the test suggested by Baylis is, of course, possible and seems almost necessary if the test is ever to be of use to the smaller water treatment plant. It has been suggested that powdered carbons might be compared on the basis of phenol adsorbed by 10 p.p.m. of carbon from a solution containing 0.10 p.p.m. of phenol during 2 hours of stirring. The amount of phenol could be determined by a direct colorimetric method without distillation and a great deal of time and labor saved. That comparable results can be obtained is indicated in the results of two laboratories, Lab. A using the distillation method, and Lab. B the direct method.

	Residual Phenol in a 0.10 P.P.M. Solution Treated with 10 P.P.M. of Carbon and Stirred 2 Hours	
	Lab. A	Lab B
Carbon X	0.059	0.058
Carbon Y	0.053	0.054

*See Water Works and Sewerage—September and October, 1932.

The Effect of Physical Characteristics

An objection to all of these indirect methods so far suggested is the absence of any attention to the possible effect of the physical properties of the carbon involved. Any test having either a high concentration of carbon with respect to the adsorbed material, or the opposite; or any test that requires either long or violent agitation tends to measure the "total" sorptive power of the carbon and neglect the rate of adsorption, or what might be termed the "initial sorption." The rate of adsorption may be decidedly important.

For instance, when two carbons are available which have the same *total* sorptive capacity, if one carbon has a much slower *rate* of adsorption than the other, a material difference may be noted when these carbons are applied to the filter influent of a water plant. Several odor results under these conditions suggest that filtration through the carbon settled out on the sand is of little benefit, and that the greater part of the adsorption of the taste and odor takes place *while the carbon was in suspension.* Tests have also indicated that adsorption of tastes and odors is probably not instantaneous, as has been suggested by others.

It is also of interest to note that the ratio of material adsorbed by two carbons may vary widely for different carbon dosages. Results from a commercial laboratory testing the phenol adsorption of two carbons are available to illustrate this point.

Results of phenol adsorption tests on two commercial carbons. P.p.m. phenol removed at the dosages given.

TABLE VI

	Carbon 10 P.P.M.	Carbon 20 P.P.M.	Carbon 30 P.P.M.
Carbon A	0.037	0.067	0.084
Carbon B	0.062	0.085	0.097
Ratio of Phenol Removal (B/A)	1.67	1.27	1.15

With a dosage of 30 p.p.m. Carbon B removed only 15 per cent more phenol than Carbon A; at 20 p.p.m. 27 per cent more; at 10 p.p.m. 67 per cent more. This is apparently due to a physical difference between these carbons—probably the fineness or dispersibility. That such differences exist is illustrated in the results of a test made by Roy S. Allen of Bloomfield, New Jersey, on 4 commercial carbons that are on the market.

TABLE VII

Sample	Particles Per Gram	Average Particle Volume Cu. Micra	Average Particle Diameter Micra
Carbon C	92,500,000,000	6.18	1.8
Carbon D	23,760,000,000	20.4	2.75
Carbon E	6,110,000,000	93	4.55
Carbon F	38,000,000,000	15	2.47

Summary

The results presented in this paper and information collected, from various sources, it is hoped may serve to start investigations which will clear up some of the questions involved in evolving a standard method of evaluating carbons. The writer is of the opinion that any method selected must give results which can be counted on to be paralleled in plant performance and must take into consideration the initial *rate of sorption,* as well as the *total sorption.* Whether this might best be done by making a phenol adsorption test at a much shorter time of stirring than the 2 hours recommended by Baylis (a combination of short and long stirring), or by determining in some manner the influence of physical characteristics that affect the efficacy of carbons used in water purification, remains to be established. All of these factors should, however, be considered.

In the writer's opinion it would be a mistake, at the present time, to set up some *single* arbitrary laboratory method and attempt to correlate field data with that alone.

▼

Maryland Water Resources Commission Submits Report

The commission appointed under an act of the 1931 session of the General Assembly of Maryland submitted its report to the Assembly last January. The report recommends the creation of a permanent Water Resources Commission of Maryland, with general powers to formulate a water conservation policy to control the priority, purpose, period, place and quantity of use of water, and to provide for continuity of stream gaging and for the supervision of dams. A summary of the findings of the commission follows:

1. Maryland's fresh-water rivers and smaller streams now supply approximately 1,240,000,000 gallons of water per day. Of this amount, 252,000,000 gallons per day are used for public water supply, 59,000,000 for industry and 928,000,000 for steam power sation use. Less than 14,000,000 gallons per day are obtained from underground sources.

2. By 1950, approximately 1,580,000 people within the state, and 800,000 elsewhere (practically all within the District of Columbia), or a total of 2,380,000 persons will require water. Their public water supply demand will be in the neighborhood of 350,000,000 gallons per day. Their probable minimum total requirements, including industrial and steam power station uses, will be 1,500,000,000 gallons per day in 1950.

3. The State of Maryland has established no policy and passed no laws with respect to the conservation, allocation or regulation of water supply uses, either as to priority, purpose, period, place or quantity of use. Although the state, in principle, owns all of the waters within its borders, their uses have not been pursued with any underlying principle of public benefit in view. The practice has been largely determined by chance, with the results at times contrary to public benefit.

4. The streams of the state are highly variable in flow and with few exceptions no effective regulation of their discharges has taken place. The absence of regulation has resulted in hazards of flood and of drought. Examples of objectionable and costly results of non-regulation are cited on the Susquehanna River, the Potomac River, the Patapsco River, the Patuxent River, Seneca Creek, Antietam Creek, Rock Creek and Northwest Branch.

5. The State of Maryland has established no long term policy for the gaging of the flows of its streams. Its operations have been discontinuous, intermittent and haphazard. The necessity of continuous long term, elementary bookkeeping of stream flows, one of the richest resources of the state, cannot be overemphasized.

6. No agency exists in the State of Maryland to which the task is delegated of reviewing the design and of supervising the construction of dams, in spite of the fact that dams have collapsed in Maryland and elsewhere with much destruction of life and property. Maryland is one of the few states in this country in which such an agency has not been established.

The commission consisted of Abel Wolman, chairman; F. H. Dryden, Thomas W. Koon, E. B. Mathews, Richard Mommers, Robert B. Morse and Philip B. Perlman.

CLARIFICATION OF SEWAGE WITH FERRIC CHLORIDE—DEVELOPMENTS AT PALO ALTO, CALIF.

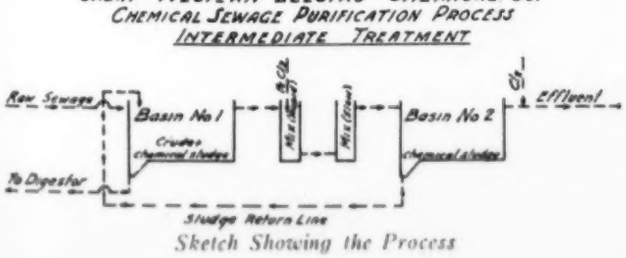
By **RALPH A. STEVENSON**
Research Engineer, Great Western Electro-Chemical Co., Pittsburg, Calif.

Ralph A. Stevenson

CHEMICAL purification of sewage is not new, having been practiced quite extensively before the advent of biological processes. As practiced in the early days, chemical purification was accomplished by adding a coagulant to raw sewage. A combination of ferrous sulfate and lime was most generally used. Such treatment was quite successful in removing suspended matter, but was accompanied by numerous disadvantages. The effluent, though usually clear, was unstable and soon became turbid and more odorous than the incoming raw sewage. A large volume of sludge was produced, at times doubling the weight of dry solids to be disposed of. A lack of stability and concurrent odor of the effluent was probably due to the fact that the caustic lime brought into solution an amount of organic matter that would decompose when the causticity was later neutralized by carbon dioxide absorbed from the air.

In operating the Great Western Electro-Chemical Company's experimental sewage purification plant at Palo Alto, we have not found it expedient to use lime and employ ferric-chloride alone as the coagulant in addition, the coagulant has been applied in a more useful manner, namely, by utilizing the "spent" ferric hydroxide formed, in the reaction effected in the secondary tanks, as an aid to plain subsidence of the raw sewage in the primary settling stage. The process consists essentially of the application of ferric chloride to a settled sewage (primary tank effluent) and the return of all of the resulting ferric hydroxide containing sludge to the incoming crude sewage as indicated in the accompanying sketch.

Ferric hydroxide reacts with hydrogen sulfide as does ferric chloride, so that the return of the ferric hydroxide from the second basin to the incoming raw sewage fixes hydrogen sulfide at the entrance to the plant, thus reducing odors. It materially aids sedimentation in the first basin. In addition it serves as an aid to vacuum filtration. By "fixing" the volatile hydrogen sulfide and increasing sedimentation in the first basin it is possible to use a considerably reduced amount of ferric chloride in the secondary or final clarification.



Sketch Showing the Process

When the work was started at Palo Alto it was at first proposed to develop a more complete treatment process using three stages of sedimentation. The removal of much of the dissolved organic matter by adsorption was to be accomplished by recirculating a large volume of floc in the third stage. Recirculated sludge was being regenerated by treatment with chlorine prior to reuse. Among the various arrangements tried was one in which 1 grain per gallon of ferric chloride was added to mixing tanks between the first and second basin and the sludge from the second basin was returned to the incoming raw sewage. We found that the effluent of the second basin contained very little suspended matter, and several authorities inspecting the plant expressed the opinion that such effluent would be perfectly satisfactory for disposal in many places. A simplified two stage process and its development is the subject of this paper. All of the work was accomplished at the Palo Alto experimental plant.

The More Recent Developments

The sewage employed was entirely of domestic nature, having a B.O.D. value of 306 p.p.m. and containing 290 p.p.m. suspended solids on the average. Free oxygen was never present and hydrogen sulfide, to the extent of about 4 p.p.m., was usually present.

A 75 gpm. sewage pump delivered sewage (already passed through a half-inch bar screen) to an overflow box where 25 gpm. was continuously by-passed to the experimental plant—the remainder returning to the sewer. The plant operated continuously 24 hours per day at a rate of 25 gpm.

The plant consisted of the following units, in each of which the depth of sewage was but 5 ft.:

1. Primary clarifier, 17.5 ft. long by 6 ft. wide. Retention period 2 hours 30 minutes. Through-put rate 345 gal. per square foot per day.
2. Two circular mixing tanks in series, each 4 ft. in diameter.
3. Final clarifier 12 ft. long by 6 ft. wide. Retention period 1 hour 30 min. Through-put rate 504 gal. per square foot per day.

The basins were equipped with Link-Belt sludge collectors. Inlet baffles were fashioned after those in use at the Sacramento water filtration plant as designed by Charles Gilman Hyde. These consisted of curtain walls with six 2 in. by 2 in. openings over the upper ⅔ of the depth, with a 6 in. by 6 in. baffle plate set 3 inches in front of each opening.

The mixing tanks were each equipped with two paddles hung on a cross arm suspended from a central vertical driving shaft. Each paddle face was equal to ⅛th of the vertical cross section of the tank. In the first tank the paddles were rotated at a speed of 10 r.p.m. and in the second tank at 3 r.p.m. Thorough mixing was obtained in the first and maximum floc developed in the second mixer.

Results Secured

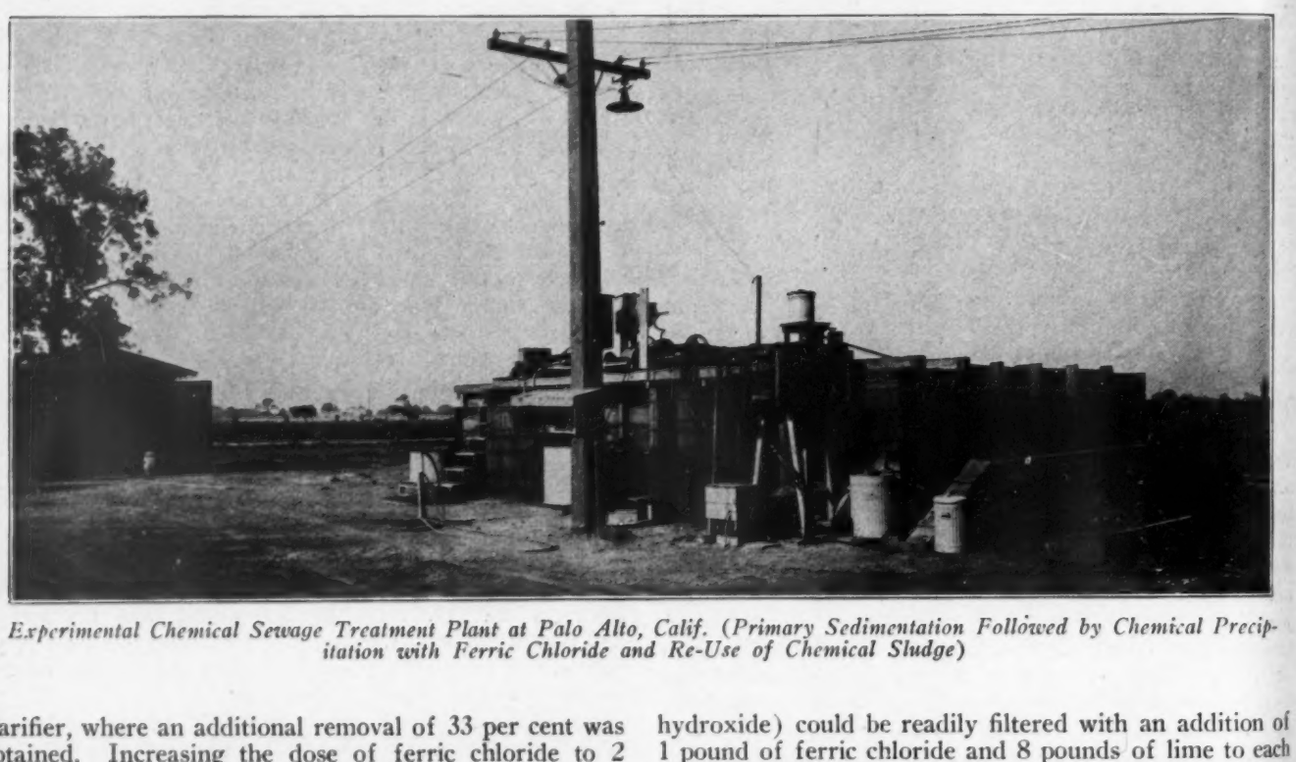
The object of the experiments with this process was to obtain the maximum reduction of suspended matter with the least amount of chemical. Ferric chloride was used in preference to alum as the coagulant because iron hydroxide is heavier than aluminum hydroxide and also because it will react with hydrogen sulfide.

Throughout a month of continuous operation the primary clarifier removed an average of 50 per cent of the suspended solids. The effluent from this basin was then coagulated with 1 grain per gal. of ferric chloride ($FeCl_3$) and allowed to settle for 1.5 hours in the final clarifier, where an additional removal of 33 per cent was obtained. Increasing the dose of ferric chloride to 2 grains per gal. accounted for an increased removal of but 3 per cent of the B.O.D. and the reduction of suspended solids was not improved. Increasing the retention period of the coagulated sewage to 3 hours did not materially affect the results.

One month's operation as above described produced an 83 per cent removal of suspended solids and 65.7 per cent reduction of B.O.D. (See Table I.) The effluent was slightly opalescent, practically free from odor and had a chlorine demand of 6 p.p.m. on the average. Samples of the chlorinated effluent remained odorless indefinitely when kept in stoppered bottles and even the unchlorinated effluent remained odorless for a week or more when kept in the same manner.

The degree of purification obtained from this process proved to be intermediate between that from plain subsidence and complete treatment such as is obtained from sprinkling filters or the activated sludge process. For example, plain subsidence will usually produce a 50 per cent reduction of suspended solids and a removal of 35 per cent of the oxygen demand value. The finely divided particles left in suspension after plain subsidence are highly putrescible and quite often the effluent is offensive to sight and smell. In comparison, the chemical treatment of the settled sewage produced an effluent which was quite clear and odorless. The sludge from the secondary clarifier (approximately 80 per cent ferric hydroxide) was returned to the incoming raw sewage, where gentle agitation helps to mix the sludge uniformily and increases the size of particles and the primary settling is improved. The ferric hydroxide combined with the hydrogen sulfide to produce ferrous sulfide, and thereby reduced odors at the entrance to the plant. A dose of 1 grain per gallon of ferric chloride seems to be capable of removing 5.4 p.p.m. hydrogen sulfide.

Another important feature in returning the iron bearing sludge is its effect on the character of the sludge to be disposed of. Experiments carried out at the Palo Alto experimental plant by Oliver United Filters, Inc., disclosed that the combined sludge (containing the ferric hydroxide) could be readily filtered with an addition of 1 pound of ferric chloride and 8 pounds of lime to each 100 pounds of dry solids in the sludge. Results hitherto reported on crude sludges were achieved only by the addition of at least twice as much ferric chloride and roughly twice as much lime.



Experimental Chemical Sewage Treatment Plant at Palo Alto, Calif. (Primary Sedimentation Followed by Chemical Precipitation with Ferric Chloride and Re-Use of Chemical Sludge)

The dose of 1 gr. per gal. ferric chloride is equivalent to 142.8 pounds of 100 per cent ferric chloride ($FeCl_3$) per million gallons. This amount of ferric chloride will react to form 94 pounds of precipitated ferric hydroxide.

At Palo Alto the removal of dry solids has average 1800 pounds per million gallons for the combined process as compared with the observed 1400 pounds removal per million gallons for plain single stage settling. Such removals produced 7,310 and 4,970 gallons sludge per million gallons sewage respectively—the increase of 2,340 gallons being that created by the chemical treatment.

Estimated Chemical Costs for the Treatment

Sterilization of Effluent—	
10 p.p.m. Cl required	
83.3 lbs. at 3 cents	$2.50
Coagulation—	
1 grain $FeCl_3$ per gal. required	
142.8 lbs. $FeCl_3$ at 3 cents	4.28
Sludge Conditioning—1800 lbs. per M.G.—	
1 per cent $FeCl_3$ and 10 per cent Lime	
18 lbs. $FeCl_3$ at 3 cents	0.54
180 lbs. Lime at 0.6 cents	1.08
Total	$8.40

The use of automatic chemical feed devices will keep down labor costs.

TABLE I—OPERATING DATA—EXPERIMENTAL SEWAGE PURIFICATION PLANT—PALO ALTO, CALIF.

1932.	Settleable Solids. 2 Hrs. Raw.	Suspended Solids. Raw.	Suspended Solids. Per Cent Eff.	Suspended Solids. Per Cent Red.	B. O. D. Raw.	B. O. D. Eff.	B. O. D. Per Cent Red.	pH. Raw.	pH. Eff.	Sludge. Per Cent 2-Hour Settling Solids.	Sludge. Gals. Per M. G. Sewage. Raw.	Sludge. Gals. Per M. G. Sewage. Comb.	Sludge. Per Cent Moisture. Raw.	Sludge. Per Cent Moisture. Comb.	Sludge. Dry Solids, Lbs. Per M. G. Sewage. Raw.	Sludge. Dry Solids, Lbs. Per M. G. Sewage. Comb.
Sept. 14	6.5	200	20.0	90.0	300	101	66.4	7.6	6.8	28	....	7,370	...	97.0	....	1,820
Sept. 15	6.0	300	20.0	93.3	319	126	60.5	7.6	7.0	25	....	6,060	...	96.8	....	1,620
Sept. 16	5.0	320	40.0	87.5	280	108	61.4	7.6	6.8	23	....	7,300	...	97.1	....	1,660
Sept. 17	5.0	220	40.0	81.7	319	126	60.7	7.6	6.8	18	....	5,350	...	96.8	....	1,450
Sept. 18	..	...	...	...	...	...	...	..	..	..	....	....	...	...	....	....
Sept. 19	8.0	300	40.0	86.6	365	99	72.7	7.6	7.0	23	5,820	....	96.7	...	1,600	....
Sept. 20	8.0	260	20.0	92.3	337	126	62.5	7.6	7.0	18	4,560	....	96.8	...	1,220	....
Sept. 21	9.0	260	40.0	84.6	375	107	71.4	7.6	7.0	20	5,450	....	96.4	...	1,630	....
Sept. 22	5.0	200	20.0	90.0	356	75	78.7	7.6	7.2	19	3,970	....	96.5	...	1,160	....
Sept. 23	8.0	520	60.0	92.3	356	112	68.5	7.6	7.2	18	4,390	....	96.6	...	1,260	....
Sept. 24	8.0	200	40.0	80.0	277	96	65.2	7.6	7.0	20	5,250	....	97.2	...	1,210	....
Sept. 25	..	...	...	...	...	...	...	..	..	..	....	....	...	...	....	....
Sept. 26	7.0	320	20.0	93.6	326	129	60.5	7.6	7.2	39	....	9,100	...	97.4	....	2,280
Sept. 27	5.5	480	120.0	75.0	326	150	54.0	7.6	7.2	26	....	6,590	...	97.1	....	1,580
Sept. 28	7.0	260	40.0	24.6	356	150	57.7	7.6	7.2	40	....	10,100	...	97.0	....	2,530
Sept. 29	7.0	240	20.0	91.6	337	99	70.5	7.6	7.2	35	....	7,150	...	97.0	....	1,810
Sept. 30	5.0	200	100.0	50.0	238	130	45.4	7.6	7.2	32	....	7,130	...	96.8	....	1,890
Oct. 1	8.0	180	80.0	55.5	223	85	62.0	7.6	7.2	28	....	6,950	...	96.8	....	1,890
Oct. 2	..	...	...	...	...	...	...	..	..	..	....	....	...	...	....	....
Oct. 3	8.0	320	60.0	81.2	240	62	65.9	7.6	7.2	21	4,710	....	96.7	...	1,300	....
Oct. 4	8.0	480	40.0	91.6	280	79	64.6	7.6	7.2	25	5,470	....	96.6	...	1,550	....
Oct. 5	6.5	...	...	...	256	110	57.0	7.6	7.2	21	....	....	...	...	....	....
Oct. 6	7.0	480	40.0	91.7	250	84	65.3	7.4	7.3	20	4,080	....	97.0	...	1,020	....
Oct. 7	4.5	...	20.0	...	319	98	69.3	7.4	7.3	20.5	5,090	....	97.0	...	1,275	....
Oct. 8	7.0	160	40.0	75.0	259	100	61.4	7.6	7.4	20.5	4,890	....	96.4	...	1,470	....
Oct. 9	..	...	...	...	...	...	...	..	..	..	....	....	...	...	....	....
Oct. 10	7.5	280	20.0	85.7	345	20	94.2	7.7	7.4	28.5	5,680	....	96.2	...	1,800	....
Oct. 11	7.5	200	40.0	80.0	...	...	...	7.7	7.4	27	5,250	....	95.8	...	1,840	....
Total .....Aver.	6.8	290	42.6	83.4	306	106	65.7	7.6	7.1	24.8	4,970	7,310	96.6	97.0	1,410	1,853
Max.	9.0	480	1.20	93.6	375	150	94.2	7.7	7.4	40	5,820	10,100	97.2	97.4	1,840	2,530
Min.	4.5	160	.20	50.0	223	20	45.4	7.4	6.8	18	3,970	5,350	95.8	96.8	1,020	1,450

Summation

Sanitary engineers have heretofore employed only two alternative methods of sewage treatment. The first, producing the minimum amount of purification, consists of settling in plain or in Imhoff tanks. When this so-called primary treatment proved insufficient, treatment of the settled liquor by a biological process was added. Primary treatment reduces suspended matter by 50 per cent and B.O.D. by 30 per cent, producing an effluent which is putrescible, unsightly, odorous perhaps, and eventually offensive. To the contrary a very high grade effluent may be obtained in a more complete oxidation process—one entirely unobjectionable under practically all conditions. In many instances the former may prove unsatisfactory and the latter may be more than is needed. The intermediate (chemical) process under development at Palo Alto is proposed to fill the gap between the two serving at once as a practical and economical means of attaining an end.

▼

Ohio Cities Adopt Sewer Rental Plan

Each year sees more Ohio municipalities availing themselves of the opportunity of financing sewage disposal by a direct charge to users of the sewer systems. In 1932, Lima, Delphos, Orrville, Cambridge, Grandview, Norwalk and Arlington enacted sewer rental ordinances, and Findlay is the first one in 1933 to adopt the sewer rental plan. This makes a total of 27 municipalities operating under this plan. The Ohio Health News of Feb. 1 comments farther on this as follows:

All municipalities are faced with the necessity of making drastic reductions in general operating expenditures. Many functions of city government can be reduced only so far, there being definite minimums beyond which it is not possible to go. Among these functions is the operation of the city's sewage disposal works. The service charge for sewer use is a logical and practical way out of the financial dilemma which confronts municipalities, and may even be the means of balancing the budget as was the case in one of the cities named above. Another city is having difficulty in securing a sufficient allocation of funds for the sewage works and is considering the sewer rental as a means for raising an amount representing the difference between the maximum funds that can be allocated in the budget for operating the plant and the larger amount which must be raised to operate the plant at a minimum of cost.

Municipalities faced with the necessity of either constructing new sewage treatment works or effecting improvements to existing plants are contemplating applying to the Reconstruction Finance Corporation of the Federal government for loans and it is here that the plan of a service charge for sewer use is applicable. The R. F. C. can loan money only for projects which are self-liquidating in character. It has been definitely stated that the R. F. C. considers sewage disposal projects financed by sewer rental as being in the class of improvements for which loans can be granted.

Financing municipal water works operation has been probably the least difficult of all city enterprises in these times of stress. That is particularly fortunate in view of the importance of proper public water supplies. The sewer system can be placed on the same basis by operating it on a utility basis by the adoption of the sewer rental plan. No one can deny the necessity of continuing the operation of a sewage disposal works as efficiently as possible. There are also many municipalities in Ohio where capital investments in new sewage works cannot be avoided or delayed. City officials, therefore, can hardly neglect serious consideration of the sewer rental plan.

▼

A Request

The Committee of the A. W. W. A. on Taste and Odor Problems is desirous of making contact with every man who has had experience with the Spaulding and other methods of evaluating odors or tastes in water. In case you have had experience which would prove of possible value to this committee in evaluating proposed methods for these determinations, kindly communicate with Martin E. Flentje, Chairman, care Supervising Engineers, Inc., Greensburg, Pa.

WATER TREATMENT ON PACIFIC LINES OF SOUTHERN PACIFIC

(More Especially Zeolite Treating)

By DENNISTOUN WOOD

Engineer of Tests,
Southern Pacific Railway Co., San Francisco, Calif.

Dennistoun Wood

I AM presuming that all who read this are familiar with the lime-soda and Zeolite processes and am not going into details as to these methods of softening. They are thoroughly covered in various articles throughout the technical literature and the process of Zeolite softening for laundry purposes and stationary boiler work is not at all new. However, the Southern Pacific was a pioneer in the use of Zeolite treatment for softening locomotive feed water and hence a description of what is being done in that way may be of some interest.

For over 35 years, the Pacific Lines of the Southern Pacific, which extend from El Paso, Tex., to Portland, Ore., and from San Francisco, Calif. to Ogden, Utah, have had wayside softener for treating hard waters used in locomotives and until 1923, all of these softeners were of the lime-soda type.

In softening with the lime-soda process, the operator has to be fairly skilled, or over-treatment may occur with consequent trouble from foaming water in locomotive boilers. Furthermore, the disposal of sludge resulting from treatment has to be taken care of and this is sometimes a serious consideration. There were a number of locations on our lines where conditions had arisen since the installation of lime-soda softeners that made it necessary to change method of operation because sludge could no longer be disposed of. We tried using Navy Boiler Compound in these wayside plants, but it gave trouble, as the injectors on the locomotives became choked with deposits of scale.

First Installation of Zeolite Softeners

In October, 1923, a Zeolite water softener was put in service in the Los Angeles passenger station to furnish soft water for the stationary boiler and use about the building and a little later in the same year, a Zeolite softener was put into use at West Oakland, Calif., to furnish soft water for washing purposes in the laundry and to furnish feed water for the laundry boiler. The results of treatment, both at the Los Angeles station and the West Oakland laundry, were so satisfactory for the stationary boilers that the thought occurred that such softened water could be used equally well for locomotives and that by doing this, we would get away from the various troubles experienced with lime-soda plants and have a method of treatment which would be nearly fool-proof as far as causing trouble on locomotive runs, the only things to be watched being that the men did not waste salt at the plants and that the locomotive engineers used reasonable care in keeping down the concentration of the water in the locomotive boilers to prevent foaming.

In order to determine whether Zeolite softened water could be satisfactorily used with locomotives, arrangements were made for temporary connections at the West Oakland laundry, so that one or two yard switch locomotives could be furnished with the softened water. We had to make our own trials as we were unable to find where other railroads in the United States had made any use of Zeolite treated water for locomotive purposes.

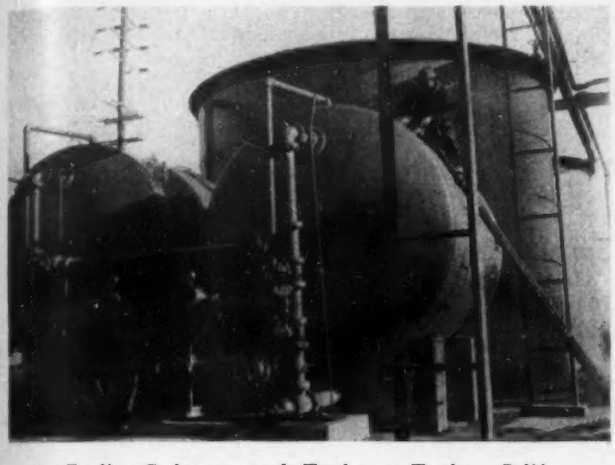
A Small Zeolite Softener During Erection in California on Southern Pacific System

Installations for Softening Locomotive Feed Water

The results obtained with the experiments at West Oakland were such that we considered we were justified in obtaining more Zeolite water softeners to be used for locomotive feed water. The Zeolite water caused the old scale in the boilers to come off and after this the flues and sheets were kept practically clear of scale formation and there was no difficulty found in handling the water as regards foaming. A third Zeolite water softener was erected in 1924 at our Los Angeles general shops to furnish soft water for the stationary boilers and for the locomotives operating out of the roundhouse at that point and from that time on we have been installing Zeolite plants over the lines until at the present date we have a total of thirty-six Zeolite water softeners, of which thirty-two furnish soft water to locomotives. The largest has a capacity of 1,200,000 gallons per day, the smallest 28,000 gallons per day, and we are

now arranging to install six additional Zeolite softeners for locomotive use.

We find that when using the Zeolite softened water, it is necessary to insist that the engine crews blow off the boilers systematically enroute and we have provided the means by making the blow-off valves readily accessible to the engine crews and by placing mufflers on



Zeolite Softeners and Tanks at Taylor, Calif.

the blow-offs so that they can be used in congested territory. We also find in certain districts that it is necessary to use anti-foam boiler compound in conjunction with the Zeolite treatment, the compound being used as required on the locomotive. However, when we consider the tremendous savings made by using the soft water, the small additional cost of compound is negligible.

We soften on an average, about 12,000,000 gallons of water per 24 hours in the Zeolite plants. The Zeolite treated water is free of lime and magnesia solids and we find that in their absence the oxides of silica, iron and alumina no longer form a scale. Therefore, the flues and sheets are free of scale formation in the boilers using Zeolite softened water.

Results of Treatment

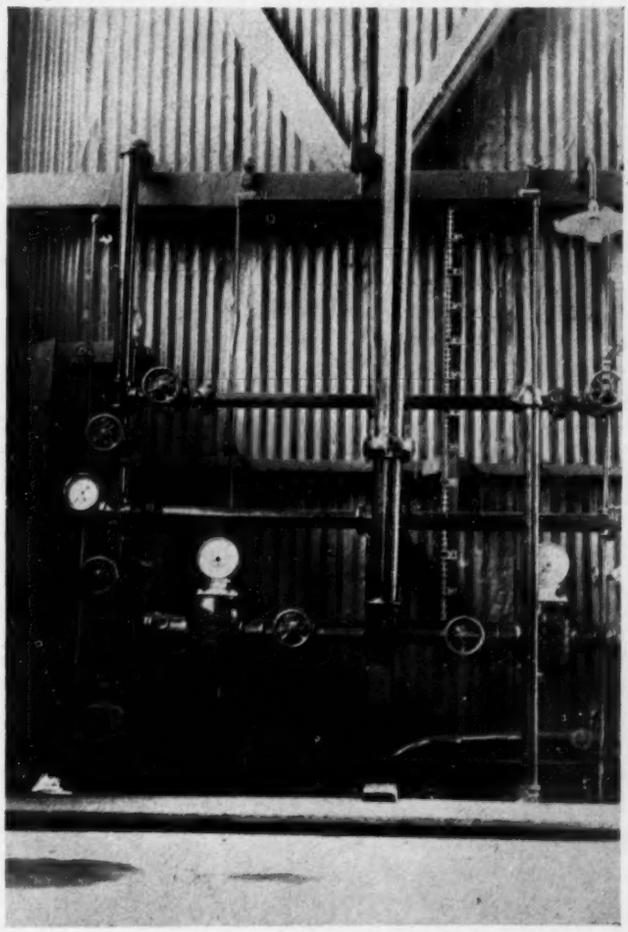
When we first used Zeolite treating plants, we were severely criticized by experts on water softening. We were told that we would experience trouble from caustic

Zeolite Plant at El Paso, Tex. Softener Is Shown in Rear of Valve House; Brine Storage Tank in Foreground

embrittlement and many reasons were advanced why we should not use the Zeolite treated water. Observation has shown us that we are having no trouble from caustic embrittlement and the results of the treatment are extremely good. Not only have we watched boiler plates closely for signs of embrittlement, but test pieces in an overstrained condition, have been placed in boilers supplied with Zeolite softened water, at various localities, and none have shown signs of this condition. It should be borne in mind, however, that the installation of a Zeolite softener depends on the character of the water and we are fortunate in having waters on our lines where this system of treatment can be used to advantage.

We have found some trouble with the eating away of brass fittings used in the boilers. Some of these fittings we have been able to replace with steel fittings and we feel justified in renewing the remaining brass fittings more frequently on account of the savings made in prevention of scale.

The comparative cost of operating a Zeolite softener as compared with lime-soda system will depend largely on the locality. With us where salt is readily available at a reasonable cost, we find that the cost to operate a Zeolite softener is slightly less than that of a lime-soda plant, but the opposite may be the case in other parts of the country.



Valve Arrangement on Zeolite Softeners at Phoenix, Ariz. Softeners Are Outside of the Building

On account of the character of the waters that we are softening, we have not found it necessary to install lime softeners ahead of the Zeolite plants in order to remove some of the lime and magnesium carbonate. Our Zeolite softeners work unaided in this respect.

The questions as to whether to use natural green sand or synthetic mineral and whether to use down-flow or up-flow plants, are largely determined by local conditions. Less water is used with the up-flow than the down-flow in the preparation or regeneration period and this may be of importance where the cost of water is

high or where water is scarce. On the other hand the down-flow type seems to have in general a greater "over capacity" than the up-flow. First costs also may be a factor as between types of plants and kinds of Zeolite.

Characteristic Waters Softened

The following table contains analyses of some characteristic waters that are softened to zero hardness by the Zeolite process:

TABLE I

(Figures Show Grains Per U. S. Gallon)

Location	Carlin, Nev.	San Luis Obispo, Cal.	Oxnard, Cal.	Taylor, Cal.
Calcium Carbonate	8.98	11.95	10.38	10.79
Calcium Sulphate	0.00	0.70	12.59	2.27
Calcium Chloride	0.00	0.00	0.00	0.00
Magnesium Carbonate	2.92	10.44	1.22	2.22
Magnesium Sulphate	0 00	6.82	7.52	5.07
Magnesium Chloride	0.00	3.56	0.00	0.00
Oxides of silica, iron and aluminum	3.03	0.47	1.87	1.87
Total Incrustants	14.93	33.94	33.58	22.22
Alkali Carbonates	.47	0.00	0.00	0.00
Alkali Sulphates	8.51	0.00	16.27	4.90
Alkali Chlorides	4.72	8.69	3.85	6.48
Total Non-incrustants	13.70	8.69	20.12	11.38
Total Solids	28.63	42.63	53.70	33.60

The large brine storage vat at Surf, Calif., may be of interest; such storage vats are used in our general practice and are large enough to contain two carloads of salt. We purchase the salt in bulk and it is wheeled from the car to the top of the storage sump and dumped into the sump through traps. We are able to purchase the salt at a lower price when bought in bulk and save in the handling. The storage vat is of concrete. Recently we have taken old tanks from tank cars, welded two together, end to end, and cut the necessary trap openings in the top. We find these tanks very satisfactory. With a concrete vat, unless the concrete is poured continuously, leakage of brine may take place along the line between pouring occurs.

A picture is shown of one of our Zeolite water softeners in the course of erection and before it was enclosed in a building and it may be interesting to note in connection with this matter, that where the climate is mild it is only necessary to house the valves and gauges of the plant so that the operator can be protected from the rain. The Zeolite mineral containers and the brine storage vat may be left in the open.

In general it is not necessary to have special attendants for the Zeolite plants. They can be located near power houses or stations, where men doing other work can look after them also.

We still have a number of lime-soda softeners on our lines and it is only fair to say that the results obtained from them are extremely good; they produce a water having an average hardness of about 3 grains per U. S. gallon and when the treatment is properly done, the water is not as liable to cause foaming as that from the Zeolite plants. In the last few years we have operated our lime soda plants using sodium aluminate with them. The latter has been a factor in reducing the amount of scale forming matter in the treated water.

In closing I wish to point out the fact that no sweeping rule can be made regarding the type of water softener to be installed at any point; each project must be considered on its own merits. Some waters will be susceptible of treatment by the Zeolite process, others should be treated with the lime-soda process. Each has its field.

References to articles on Zeolite Treatment on Southern Pacific Company, Pacific Lines, for those interested in greater detail:

"Zeolite Method" by C. W. Sturdevant. Proceeding of Pacific Railway Club, Aug. 13, 1925.

"Zeolite Treatment" by C. W. Sturdevant. Railway Review, Oct. 9, 1926.

"Use of Exchange Silicate (Zeolite) Water Softeners in Railroad Practice" by G. L. Baxter, Industrial and Engineering Chemistry, July, 1928.

▼

Milwaukee Held to Infringe Activated Sludge Patents

Judge F. A. Geiger of the United States Court at Milwaukee has decided that the Jones patents covering the "Activated Sludge" system of sewage treatment are valid. The decision was rendered in a suit by Activated Sludge, Inc., against the City of Milwaukee.

Activated Sludge, Inc., a Delaware corporation, owns the United States patents, granted to Walter Jones, a British engineer, now deceased.

The present decision is of widespread interest because the Activated Sludge system of sewage treatment is used by many American cities, including Chicago.

The Sanitary District of Chicago, which employs the Activated Sludge process, is defending a suit on the same patents, before Federal Judge Walter C. Lindley. The trial of the action against the Sanitary District of Chicago has been continued several times pending a decision of the Milwaukee suit, which has been regarded as a test case, but is now set to be resumed on April 3rd.

Judge Geiger, in a seventy page opinion, finds that the Activated Sludge process was revolutionary in character; that Jones was the inventor; that his patents are valid; that the fifteen million dollar sewage treatment plant of the City of Milwaukee infringes, and that Activated Sludge, Inc., is entitled to a decree on its bill for an injunction and accounting. A counterclaim by the City of Milwaukee against Activated Sludge, Inc., was dismissed.

The Milwaukee case, trial of which occupied several weeks in May 1929, was held under advisement until recently. Copies of the decision were available in Chicago for the first time on February 14th.

The Milwaukee suit was tried by two firms of Chicago lawyers—Williams, Bradbury, McCaleb & Hinkle representing Activated Sludge, Inc., and Parkinson & Lane representing the City of Milwaukee.

[*Note.*—The above has been taken from a statement supplied by the attorneys representing Activated Sludge, Inc., in an attempt to give an unbiased statement of fact. An appeal, if taken, lies to the U. S. Circuit Court of Appeals for the 7th Circuit, which sits in Chicago.—EDITOR.]

▼

JAPANESE CITY MAY USE SEWER SERVICE CHARGE—The desirability of financing the operation of sewage treatment plants by sewer service charges, as practiced in Ohio, has spread beyond American shores across the Pacific to far-off Japan, according to the Jan. 15 issue of Ohio Health News. K. Takata, city engineer of the city of Kyoto, Japan, recently inquired of Dayton officials concerning the operation of the sewer rental in that city. W. W. Morehouse, Director of Water and Sewage Treatment, supplied Mr. Takata with all the details of the Dayton experience with sewer service charges and was later informed that knowledge of the method in vogue in Ohio would prove most helpful in enabling the officials of Kyoto in financing sewerags projects.

TILE SLUDGE REMOVAL SYSTEMS FOR WATER TREATMENT PLANTS

By EDWARD P. SCHINMAN

Chemical Engineer,
The Permutit Co., New York City

WHEREVER water is coagulated or softened by means of chemicals, the large quantities of sludge formed in these processes must be removed from the tank or basin. During recent years the rapid increase in the number of coagulation, sedimentation and softening plants has made this problem of efficient and economical sludge removal one of paramount importance.

Formerly the common method employed for coagulation of chemical softening (as distinguished from softening by base exchange—zoelite method—in which no chemicals are used and no sludge is formed) was to allow the chemically treated water to pass through one or more sedimentation tanks, arranged either in series or parallel, at a slow rate so that most of the precipitates formed settled out in the basins or tanks. After the sludge had accumulated to a predetermined level the tanks were taken out of service, drained and the sludge removed, either manually or hydraulically, and again returned to service. This system had the obvious disadvantage of requiring spare sedimentation tanks with consequent high initial investment, maintenance and operating costs.

The tile sludge removal system was developed to permit the frequent periodic removal of sludge without interrupting the operation of the basin. This sludge removal system consists essentially of a series of perforated vitrified tile laterals discharging into one or more headers to which are connected quick opening gate valves. To remove the sludge it is merely necessary to open the quick opening gate valves about once a day depending on local conditions and allow them to remain open until the sludge has been removed, the time required usually being less than five minutes.

Some factors which must be considered in the correct design of this type of sludge removal system are the physical and chemical characteristics of the sludge, size and shape of basins, etc., in addition to basic hydraulic principles. It must be remembered that the sludges formed in various treatments have definite angles of repose and this factor must also be considered. The actual design of the sludge system should be supervised by a competent engineer so that the above factors in addition to the modifications required by local engineering details may be incorporated.

The tile sludge system is so particularly adaptable to the individual problem that it is being used very extensively and its use should be considered wherever sedimentation is planned as part of the treatment. To date there have been approximately 200 sludge systems of this type installed in municipal and industrial water treatment plants in this country and Canada.

There are many reasons for the rapid growth in popularity of this system and some of these will be discussed briefly below:

Reduction in Number and Size of Basins

Basins having tile sludge removal systems operate continuously and thus overcome the inherent disadvantage of the intermittently cleaned basin. For this reason duplicate basins are not required for carrying the load during the periodic "out for cleaning" time of the intermittent basin, thus reducing the initial and maintenance cost of the plant. In the ordinary basin sludge accumulates from the time the basin is put into service and gradually decreases the effective volume. The detention period is continually being reduced and consequently the efficiency is continually being lowered until the basin is taken out of service for cleaning. A basin equipped with a tile sludge removal system operated continuously at its maximum designed efficiency.

Adaptable to Modification in Water Treatment

In some cases it may be desired to recirculate the sludge in order to increase the rate of settling and accelerate the chemical reactions. This sludge recirculation can be readily accomplished in a basin which has a tile sludge removal system.

Where activated carbon is fed in the basin for taste and odor removal it may sometimes prove economical to recover the active material by recirculating sludge and the tile sludge removal system can readily be adapted to this method of operation.

Stream Pollution Decreased

In the operation of ordinary sedimentation basins the sludge accumulates and at times, several weeks' or months' accumulation is allowed to enter the stream in one dose. Not only does this create an unsightly condition near the plant and farther downstream but it is also highly objectionable for obvious reasons. When using the tile sludge removal system the daily amount of sludge is relatively small and the dilution provided by the stream is so great that usually the disposal of the sludge causes less objectionable conditions of the stream, both near the plant and farther downstream.

Prevention of Sludge Decomposition

The sludge from waters containing large amounts of organic matter, algae, and other organisms tends to decompose, putrefy and acquire disagreeable odors when allowed to accumulate as in the ordinary basin. With the tile sludge removal system the sludge is removed before there has been sufficient time for decomposition and putrefaction.

Flexibility in Design and Operation

The tile sludge removal system can be designed and operated to desludge the basin in sections. This factor is frequently desirable not only in the design of basins for coagulation and softening but also in basins for waste water treatment where the rates of reaction and settling may vary. The writer recalls a recent design for a tin sludge recovery basin where it proved practical to design the sludge removal system so as to desludge as little as one-eighth of the basin at one time.

Negligible Cost of Operation

One of the most important considerations in the design of any treatment plant is the maintenance and operating costs. The operating and maintenance costs for sludge removal by the tile sludge removal system are negligible.

The only labor required is the manual opening and closing of a few quick opening gate valves once or twice daily depending on local conditions, requiring possibly five minutes of the operators' time. There are no moving parts; no power equipment is required for the operation of mechanical parts, and consequently no cost for power. Since the basins are not out for intermittent cleaning there is the consequent saving of chemically treated water when draining and filling the basins and also the cost of the cleaning operation.

Summarizing, it has been shown that tile sludge removal systems have the following advantages:

(a) Increased efficiency of basins.
(b) Reduction in number and size of basins required.
(c) Reduction in operating and maintenance costs.
(d) Low initial cost.
(e) Adaptability to modifications in the individual treatment.
(f) Reduction of stream pollution.
(g) Prevention of sludge decomposition.
(h) Flexibility in design and operation.
(i) Negligible cost of operation.

A detailed comparison of basins or tanks equipped with perforated tile type sludge removal system with older intermittently cleaned basins shows the decided superiority of the former and therefore the use of tile sludge removal systems should be seriously considered in the design of new projects involving sludge removal as well as for the remodeling of existing installations.

Grand Island Skates on "Activated" Ice

By CARL HEHNKE
Chairman Sewer Committee, Grand Island, Nebr.

PRIOR to 1931, the method of sewage disposal for Grand Island, Nebraska (population 18,000), was by Imhoff tank treatment with effluent disposal into the Wood River—a stream often dry. Overloading, incomplete treatment and poor supervision gave trouble. Under court orders to install a plant, the effluent from which would not create a nuisance and would contain no harmful bacteria, an activated sludge type of plant was constructed and placed in operation. The resident engineer, Mr. J. H. Hardeman of Black & Veatch, designing engineers of Kansas City, Missouri, was retained as superintendent and general supervision of plant operation was given to the designing engineers for the first year.

Topographical limitations and the desire to salvage the lift station and the old Imhoff tank as a sludge digestor, led to the selection of the old plant site for the new plant. The plant is located about 10 blocks from the post office, a few hundred feet from a residential area and just over the railroad tracks from the ball park. No offensive odors could be permitted and the court ordered the effluent to be clear and odorless. These conditions have been fully met during this past calendar year—the first full year of operation. The city administration and people living nearby have been satisfied, but the sewer committee decided to make this plant a beauty spot as well as a satisfactory utility, so they ordered the grounds landscaped, with gravel driveways, cement curbing, etc. Trees, shrubs and plants were set out, and blue grass sown. About an acre of land, held in reserve for plant extensions, was made into a park area.

With winter approaching and no good skating pond available, the sewer committee decided that since the overflow weir of the final clarifier was well above the ground level at the rear of the plant, it would be practical to put in a pipe line and valve and flood a portion of the reserve space. An earthen dike was thrown up and an oval pond about 290 by 350 ft. was created. This cost about $300. The sewage plant effluent was turned into the enclosure, and with freezing weather a down-town skating place is available. Driveways all around the pond provide easy access and parking areas. Near the final clarifier a frame shack was erected to allow skaters to change shoes, etc., in a warm place. Provision to heat this shack with sewer gas is to be made but a coal stove for the present serves that purpose. About $70 was invested for this shack.

Thus, for $370—spent practically entirely for labor and unemployment relief—a playground for young and old has been built. The average attendance daily runs to about 150, and on Sundays there are as many as 500 skaters. Public clamor is for enlarging the pond. During the summer the pond will be landscaped and perhaps transformed into a sunken garden. The sewage plant has come to be one of the best known places in Grand Island.

The Skating Pond at Grand Island's Sewage Treatment Plant. Note the Heated Shack Across the Pond to the Right Center

FIFTEENTH ANNUAL TEXAS WATER WORKS SHORT SCHOOL

A Digest of Papers on Sewage Topics

THE Fifteenth Annual Texas Water Works Short School and the meeting of the Texas Section of the Southwest Water Works Association was held at Temple, Texas, January 16 to 18. Approximately 150 were in attendance, including guests and manufacturers' representatives.

That the school was organized largely to be of aid to plant operators and is serving this purpose was evidenced by the character of the papers and by the interest taken in the laboratory sessions which continued through the first day. Lectures and demonstrations followed by the opportunity for individual members of the classes to go through the routine tests were given primarily to train the operators in making practical biological and chemical analyses. Over 60 plant operators took advantage of this important phase of the school, obtaining instruction in B. O. D. determinations on sewage, water bacteriology and the chemistry of water.

In a dinner address on **"Politics and Its Effect on City Government"** JOHN N. EDY, City Manager of Dallas, Tex., outlined the difficulties encountered in carrying out the work of municipal governments to the best interests of the people. He stated that the forces of government should be improved so that they will be efficient and non-political. He thought that the public recognizes and appreciates the difference. It was stated that in every city certain municipal improvements are needed in connection with water and sewage treatment and if they are not provided one or more of the objectives of government are not met. Need of such improvement should be fairly and frankly reported to the public in an attempt to combat influences which would cause the issue to be decided upon by means other than merit and accepted standards of public interest. His final plea was for the recognition of public service as an honorable service and worthy of the best possible efforts.

Symposium on Sewage Disposal

The first evening was completely given over to a round table discussion on **"Current Practices in Sewage Disposal,"** ably presided over by EDGAR WHEDBEE, Sanitary Engineer, City of Dallas. This symposium consisted of a number of very interesting formal papers followed by extended periods of informal discussion participated in by a large number of the operators and consulting engineers in attendance.

"Required Capacity of Separate Digestion Tanks for an Activated Sludge Plant, Based on Operating Experience at the San Antonio Sewage Plant," by W. S. STANLEY, Chief Chemist and Superintendent. By reference to actual operating data collected during the past few years Mr. Stanley formulated the capacity requirements for digestion of the solids from the San Antonio plant, finding a per capita requirement of about 5.5 cu. ft. Since this figure is higher than that usually considered sufficient for digestion of activated sludge and raw solids, Mr. Stanley reviewed a number of studies carried out at his plant. Figures were made on a basis of primary sludge obtained at an average of 4.5 per cent solids and activated sludge reaching an average of only 0.8 per cent solids, with a figure of 1.3 per cent solids obtainable for the mixture of the two. Studies revealed that a 60-day period was required to obtain a 40 per cent reduction in the volatile solids.

In an attempt to increase the solid content of the sludge the supernatant liquor from the digestion tank was piped to the incoming raw sewage channel instead of passing into the aeration tanks, which tended to alleviate bulking troubles in the aeration tanks without greatly disturbing the sedimentation in the primary tanks. Due to foaming troubles caused by adding the excess activated sludge to the digesters, it was found necessary to pass most of the excess activated sludge into the effluent canal.

Mr. Stanley reported a great deal of difficulty with boiler flues and gas meters due to the corrosive action of the digestion tank gas, resulting in the necessity of the repairing of boilers and the complete removal of meters from the line.

In discussion, W. S. MAHLIE, Chemist of Fort Worth, told of his experience in dealing with the supernatant liquor from the Fort Worth digesters and of the difficulties experienced with boilers due to the corrosive action of the gas. He felt that there was need for some type of scrubber to remove the corrosive products from sludge gas.

"A New Method of Sewage Disposal by Aeration, Coagulation, Clarification and Oxidation," by C. C. HAYS, Chemist, Waco, Tex.

Mr. Hays reported his studies of the actions taking place in contact surface aeration, employing several stages of aeration. Diffused air is blown upward through stone or tile acting as a contact surface in sewage basins. His investigations had revealed the presence of certain predominating types of organisms in the different stages of the process. The contact-aeration stages had been supplemented by a period of sedimentation after each activating stage or period. Air is supplied at the bottom of the tank at a low pressure, the air being used mostly for the supplying of oxygen to the organisms rather than for circulation effects. Periodically an increased air pressure had to be applied to tanks individually in order to loosen the gelatinous growth from the contact surfaces and transfer them to the settling units.

"Coagulation with Ferric Chloride in Sewage Treatment," by HARVEY O. BANKS, Sanitary Engineer, Palo Alto, Calif.

Mr. Banks traced the experiments carried out at Palo Alto by the Great Western Electro-Chemical Co. on the use of ferric chloride in the treatment of sewage. Interesting results of the process devised for the re-use of the coagulant were presented. In one arrangement which was described three settling basins with mixing stages between were employed. Sludge from the second settling basin was returned to the incoming sewage to aid precipitation in the first settling basis. Sludge from the third or final basin was regenerated by the addition of chlorine to the extent of 250 to 400 lbs. per million gallons, after which a portion of the regenerated sludge was added to the first settling basin, the balance going

to the mixing tanks preceding the second settling basin with the additional use of fresh ferric chloride to the extent of about 0.75 of a grain per gallon. Various other arrangements of tanks and applications of chemicals were reported and others are still to be tried.* Cost of treatment, using 1 grain of ferric chloride per gallon was estimated to be about $9.80 per million gallons.

"Making Full Use of Theoretical Considerations in Water and Sewage Clarification," by H. E. SCHLENZ, Sanitary Engineer, Pacific Flush-Tank Co.

Mr. Schlenz discussed the process of sedimentation for the purpose of suggesting means of obtaining more effective results from plain settling tanks by the proper arrangement of inlet and outlet structures, the relationship of the depth of the basin to the area, etc. The inaccuracy of judging the results to be obtained from a settling tank by a consideration of the detention time as determined by volumetric displacement was shown by describing tests on a tank having a calculated detention period of two hours through which some of the flow actually passed in from 10 to 15 minutes. The effectiveness obtained by upward filtration through a blanket of previously deposited material, he said, had been shown to be many times that obtained through ordinary downward precipitation of particles.

"Activated Carbon in Sewage Treatment," by V. M. EHLERS, Chief Engineer, State Department of Health, Austin, Tex.

Mr. Ehlers briefly reviewed the experimental work which had been conducted in various sections of the country on the use of activated carbon in the treatment of sewage. He reported that the studies under way indicated activated carbon to be effective in controlling odors from sewage, but that due to the quantity of organic matter present in the sewage the amount of activated carbon required might make it prohibitive.

"Diffuser Mediums for Activated Sludge," by FRANK C. ROE, Sanitary Engineer, the Carborundum Company, Niagara Falls, N. Y.

Mr. Roe being unable to be present, his paper was read by W. S. Mahlie. The value of good distribution of air in the activated sludge process was discussed with particular emphasis being placed on the question of absorption of air at the liquid surface and the absorbtion of the diffused air. It was stated that small bubbles have been considered desirable in order to obtain maximum contact with the sewage liquor, but this causes high pressure losses through the diffuser plates. Large bubbles, on the other hand, waste much air but are favorably considered because of the greater liquid velocity which is maintained in the tanks, resulting in the prevention of the settling of solids and the providing of maximum surface contact of liquor with the atmosphere. Present thought favors the use of the larger bubbles and a high degree of uniformity of distribution as the most practical method of aeration.

"Sewage Irrigation," as practiced at Munday Tex., was discussed by D. T. MAULDIN, City Manager. He stated that the West and Southwestern portion of Texas, where the normal rainfall is from 18 to 20 inches, presented a great field for sewage farming. Accurate records kept at Munday for three years showed that when maize sold for $25.00 per ton, the farm produced a crop of the value of $135.00 per acre.

*Elsewhere in this issue there appears an article by R. A. Stevenson which describes more recent developments at the Palo Alto station, with simplification of process resulting.

E. L. FILBY, Black & Veatch, Engineers, Kansas City, Mo., in showing moving pictures of sewage and water treatment plants, presented interesting figures in regard to water softening for municipalities where such treatment is desired. Filtration and sedimentation treatment had been figured to cost 4.8 cents per 1,000 gallons as against 5.39 cents per 1,000 gallons for softening, as based on 1931 costs.

Committee Reports Featured

An important feature of the meeting were the reports of the various committees which appeared in the February issue of WATER WORKS & SEWERAGE. The first step in the licensing of water and sewage treatment plant operators in the state was proposed in the providing of three classes of operators. It was planned to carry this licensing out on a voluntary basis for a short while to be later replaced by a compulsory measure.

The voluntary rating of the water supplies of the state also appeared to be accepted with a great deal of interest as a means of bettering the water supplies.

▼

George W. Fuller Named Chairman of Engineering Foundation

George W. Fuller

George W. Fuller, of Fuller & McClintock, New York, has been elected chairman of the Engineering Foundation to succeed H. Hobart Porter. Mr. Fuller, an internationally known hydraulic and sanitary engineer, was one of the first to make extensive investigations experimentally into the mechanical method of filtering the water supplies of cities and towns. This work, which he carried on in Louisville and Cincinnati during 1895-1899, marked the beginning of American developments in the field of water purification.

Mr. Fuller was born in Franklin, Mass., December 21, 1868. He was graduated from Massachusetts Institute of Technology in 1890, and subsequently studied at the University of Berlin. From 1893 to 1895 he was in charge of the Lawrence Experiment Station of the Massachusetts Board of Health. He has been expert adviser to numerous important American cities—his most recent large project being the Ward's Island sewage treatment works for New York City.

Other officers chosen by the Foundation were:

First vice chairman, Harry P. Charlesworth, vice president of the Bell Telephone Laboratories, New York; second vice chairman, H. C. Bellinger, vice president of the Chile Exploration Company, New York.

D. Robert Yarnall, vice president of the Yarnall-Waring Company, Philadelphia, and John V. N. Dorr, president of The Dorr Company, New York, were elected to the Executive Committee. Alfred D. Flinn was re-elected director and secretary. Arthur S. Tuttle was elected a member of the foundation's board of governors.

NOTES ON SEWAGE GAS AND A SIMPLE METHOD OF ANALYSIS

By CHARLES C. AGAR

Assistant Sanitary Engineer, New York State Department of Health, Albany, N. Y.

C. C. Agar

SEWAGE gas is produced whenever decomposition or digestion of sewage or similar organic solids takes place. This decomposition may occur in sewers, catch basins, grit chambers, tanks, and in fact any place where such solids are present. Therefore, sewage gas may be found in practically any part of a sewer system or sewage treatment plant.

The principal constituents of sewage gas are methane (commonly called marsh-gas) and carbon dioxide. Unlike illuminating gas, it does not usually contain carbon monoxide gas. Carbon monoxide is a product of incomplete combustion of carbonaceous material and only under rare conditions does it appear in nature. Dangerous concentrations of carbon monoxide may, however, be found in the sewer system if illuminating gas from leaking mains has entered sewers.

Both sewage gas and illuminating gas are combustible and highly explosive if ignited when mixed in proper proportions with air. Such gases may produce serious explosion hazards, in sewers or sewage treatment plants.

The dangerous physiological effects of illuminating gas are fairly well known but there is less general information on the dangers from sewage or sludge gas. Any non-toxic gas may cause asphyxiation or suffocation when present in quantities sufficient to seriously reduce the concentration of oxygen, and sewage gas is no exception. Depletion of oxygen from the normal 21 per cent to from 16 to 12 per cent will produce definite physiological effects and such effects become of a serious nature with lower oxygen concentrations. Oxygen concentrations of about 6 per cent or less are rapidly fatal. Recovery after exposure to non-fatal depletions of oxygen usually occurs in a short time without serious after effects.

Sewage gas also frequently contains hydrogen sulphide in concentrations varying from 0.1 per cent to occasionally as high as 10 per cent in sludge gas. Hydrogen sulphide is extremely toxic and dangerous and may be present in the gas in sewers or in the gas from sludge digestion tanks, particularly during the initial stages of digestion. This is especially true when the sewage solids are in an acid condition or where the sulphate content of the water supply is high.

Characteristics of Hydrogen Sulphide

Hydrogen sulphide has a characteristic "rotten egg" odor and is disagreeable and irritating to eyes and nose when present in relatively low concentrations. Concentrations of 0.2 per cent or more are rapidly fatal and such concentrations are usually non-detectable by odor because of immediate paralysis of the sense of smell. The presence of relatively small amounts of gas having a hydrogen sulphide content of from 1 to 10 per cent in a chamber, room or sewer having poor ventilation would soon produce lethal concentrations.

Hydrogen sulphide in combination with moisture results in corrosion of concrete and steel or iron structures unless well protected by acid resisting paints. Copper is rendered brittle by hydrogen sulphide whereas aluminum withstands its attack very well. Paints containing lead are blackened quickly on exposure to this gas, and constitute a ready indicator of its presence.

All of these considerations make it necessary for superintendents of sewers and operators of treatment plants to take unusual precautions where sewage or illuminating gas may be present. Commercial gas detectors for toxic gases are available and should be used whenever there is any question of the nature of gas in a sewer or other enclosure. Detectors for carbon monoxide and hydrogen sulphide will not, however, indicate an oxygen deficiency. Small animals and birds are sometimes used to determine the safety of the atmosphere in confined spaces. There is also a detector on the market which shows the explosive content and the oxygen content of atmospheres. Adequate ventilation of manholes and enclosures before entering is always advisable and no person should ever enter an enclosure unattended or without an emergency rope in place where gas is likely to be present.

Simple Method of Gas Analysis

In the course of a study of some difficulties experienced in the operation of sludge digestion tanks, it was found necessary to devise a simple method for determining the carbon dioxide and hydrogen sulphide content of the gas produced. Considerable variation in the fuel value of the gas had been noted. The gas also had a strong hydrogen sulphide odor and after burning gave a decided odor of sulphur dioxide. A health hazard as well as possible corrosion of equipment and structures was involved. No conventional gas testing apparatus was available and hence the following procedure was used.

(A) One hundred (100) cubic centimeters of water saturated with common salt (sodium chloride) is placed in an Erlenmeyer flask or other similar glass receptacle and the gas passed through the liquid with occasional shaking until saturated with the gas to be tested.

(B) Thirty (30) cubic centimeters of this solution is then placed in a large U bulb Smith fermentation tube and a sample of the gas then collected in the long arm.

(C) After allowing the gas to come to room temperature, the liquid elevations in the bulb and arm of the tube are balanced and a reading is made of the length of gas column in the long arm.

(D) Five (5) cubic centimeters of a 20 per cent caustic solution (sodium or potassium hydroxide) are then added and the bulb filled to the opening with the saturated salt solution. By placing the thumb over the opening so as not to entrain air and gently shaking the tube, absorption of the carbon dioxide and hydrogen sulphide will occur.

(E) The gas is again collected in the long arm, the

liquid elevations in the bulb and arm balanced, and the length of gas column in the arm measured.

A contraction in volume will be noted corresponding to the volume of carbon dioxide and hydrogen sulphide in the sample. The approximate percentage of these combined constituents may be determined. Since the hydrogen sulphide content of such gas is generally low, the results usually represent a close approximation of the carbon dioxide content. When testing digestor gas, the total volume of gas minus the volume of carbon dioxide can usually be considered combustible and principally methane.

Determination of Sulphide Gas

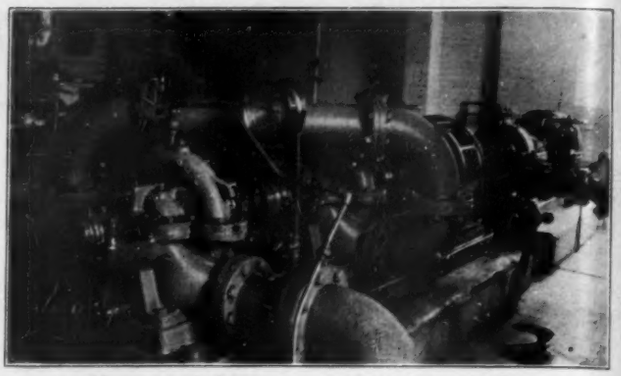
Blackening of moistened lead acetate paper or even blackening of a silver coin are simple qualitative tests for the presence of hydrogen sulphide. Where the hydrogen sulphide content of the gas is high, as may be the case with digestor gas, the approximate concentration can be determined by a procedure similar to that outlined for carbon dioxide if a few drops of an alcoholic iodine solution are used instead of the caustic absorbing solution. Concentrations of from 2.5 per cent to over 10 per cent have been determined by this method. It is especially necessary to use in this test a salt solution saturated with the gas being tested—this because hydrogen sulphide is somewhat soluble in the salt solution. For accurate determinations and for low concentrations of hydrogen sulphide, an iodimetric titration method is recommended. The sulphide gas may be absorbed by aspirating a known volume of gas through alkaline solution and the iodine titration then performed on the diluted alkali solution after acidifying slightly.

Overcoming the Cost of Obsolescence at a Water Pumping Plant

By J. Bryan Miller,
City Manager, Jacksonville, Texas

IN August of 1931 a very careful check was made on the operating efficiency of the pumping equipment installed in the Jacksonville, Texas, water works plant. Two two-stage centrifugal units of 300 and 400 gallons per minute capacity, direct connected to 30 and 40 horsepower 2300 volt motors were in operation. Since there were times during the day when both units were operated in parallel, the efficiency due to this operation was extremely low. Also, because the units had been installed about eight years ago and were of obsolete design, the efficiencies were extremely low as compared to newer type pumps.

J. Bryan Miller



These New Pumps Displaced Obsolete Equipment in the Jacksonville, Texas, Pumping Station

the units had been installed about eight years ago and were of obsolete design, the efficiencies were extremely low as compared to newer type pumps.

Actual tests made in August of 1931 showed the 400 gallon per minute unit delivered but 353 gallons per minute against a 249 ft. head with a pump efficiency of 49.7 per cent and a power consumption of 1.71 K.W.H. per thousand gallons. The 300 gallon per minute unit delivered but 271 gallons per minute against a 247 ft. head with a pump efficiency of 46.3 per cent and a power consumption of 1.64 K.W.H. per thousand gallons. The two units operating in parallel delivered but 462 gallons per minute against a 254 ft. head with a pump efficiency of 47.9 per cent and a power consumption of 1.915 K.W.H. per thousand gallons discharged into the water mains. The resulting power consumption for the year averaged 1.81 K.W.H. per thousand gallons of water delivered into the mains.

Because this figure was extremely high, as compared with efficiencies of modern pumping units it was decided to replace the larger pumping unit with one that would meet the requirements and reduce operating costs. Consequently, a unit consisting of two double suction single stage Type SK. Allis-Chalmers centrifugal pumps connected in series (with coupling and extended base for receiving the 40 horsepower motor which the city was using to pull the old unit) was purchased.

The new pump was designed to deliver 450 gallons per minute against a 260 ft. head with a requirement of 38.2 B.H.P. and a pump efficiency of 79½ per cent. The power requirements guaranteed on this unit were 1.22 K.W.H. per thousand gallons delivered.

The contract price of the new unit delivered was $743.00. The total cost installed including piping, foundation, etc., was $950.62.

The unit has been installed and has been in operation for over a year. Actual tests show it to be delivering 468 gallons per minute against 270 ft. head with a pump efficiency of 79.6 per cent and a power consumption of 1.195 K.W.H. per thousand gallons delivered into the mains.

Based on the pumping costs of the previous year this saving in actual dollars and cents represents $1,395.90 in power costs. Deduct from this the cost of the unit and you will note that the pump has paid for itself with an excess saving of $445.28 during the first year of operation.

WHY BIDDING PRICES ON PORTLAND CEMENT ARE UNIFORM

By HALBERT P. GILLETTE, Editor

RECENT advances in the price of portland cement have led to favorable comment among those who believe that business revival must be preceded by a rise in prices. On the other hand, there has been some criticism of the higher prices, and the old question has been raised as to why the new prices are so uniform. That question was not asked when the price of cement was declining, although there was the same uniformity as to bidding prices when they were "on the toboggan" as there is now when a slow climb up the hill is beginning.

Economists are unanimous in saying that nearly every commodity price is now too low to yield a normal return upon invested capital. And they are agreed that a normal profit must be earned before good times will be with us again. Why, then, are there any critics of rising

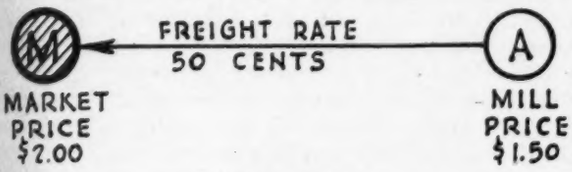


Diagram I

cement prices? Presumably because the uniformity of the bids leads to the inference that it indicates collusion among the bidders. Those who draw such an inference as to cement prices have evidently failed to consider an economic law that applies to every class of uniform product that is sold in an open market, namely, that competitive prices gravitate toward equality.

All portland cement offered for sale is required to conform to a standard specification agreed on by the U. S. Bureau of Standards, American Society of Civil Engineers, and American Society for Testing Materials. This standard is generally recognized by all users of portland cement. Thus it is that portland cement made by any reputable manufacturer is interchangeable with that made by any other such manufacturer. No enlightened buyer will pay more for one cement than for another.

As in the case of wholesale buyers of wheat, sugar or any other standardized product, cement buyers will not pay a premium for one brand of cement which is the same in quality as some other brand. This being so the price at which cement is sold in any market usually equals the lowest price at which it is quoted in that market.

The reason for uniform prices of a standardized product like portland cement was pointed out more than 60 years ago by a noted English economist, W. Stanley Jevons, LLD., M.A., F.R.S. In his book, "The Theory of Political Economy" (MacMillan & Co., Ltd., London, published in 1871) Jevons says:

"When a commodity is perfectly uniform or homogeneous in quality, any portion may be indifferently used in place of an equal portion; hence in the same market, and at the same moment, all portions must be exchanged at the same ratio. . . . Where no difference exists at all there can be no ground for preference whatever. If, in selling a quantity of perfectly equal and uniform barrels of flour, a merchant arbitrarily fixed different prices on them, a purchaser would, of course, select the cheaper ones; and where there was absolutely no difference in the things purchased, even an excess of a penny in the price of anything worth a thousand pounds would be a valid ground for choice. Hence follows what is undoubtedly true, with the proper explanations, that in the same open market, at any one moment, there canont be two prices for the same article."

To illustrate this point two examples may be cited. Many dealers handling cement have a place of business in more than one city or town; so-called line yards have headquarters in a city and branch yards in several, sometimes several hundred, towns. They ask manufacturers for quotations on cement delivered at all these towns. Second, a state may ask for bids on cement for highway building purposes delivered at numerous destinations throughout the state.

In each of these two cases the line yard and the state will probably be quoted for each of the destinations exactly the same price from each of ten or more manufacturers of cement. This naturally is considered by some people as conclusive evidence that manufacturers get together and agree on prices. How could it be possible otherwise, they ask, that exactly the same price at each several hundred destinations should be quoted by several different manufacturers? Yet the answer is simple.

Portland cement is sold delivered at a destination designated by the buyer and the price includes freight and charge for the container, usually sacks, in which the

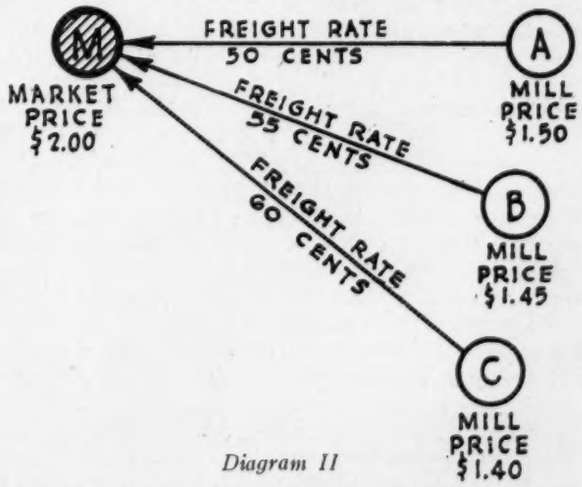


Diagram II

cement is packed. Thus the price paid by the buyer is made up of the manufacturer's price at his mill, plus freight to destination, plus charge for container. When the purchase is made from a dealer his charge for handling and his profit, of course, are included in the price paid by the ultimate buyer.

This is illustrated in Diagram I. A is the mill and M the market or destination. The freight rate from mill to market is 50 cents. The mill price (A) is $1.50 to which is added freight rate of 50 cents, making price at market $2.00. (In this illustration charge for container is ignored.)

The illustration Diagram I is perfectly simple and would remain so if each market where cement is used were supplied by only one mill. But in actual practice

there are many mills seeking business in every town or market in the country. This is illustrated in Diagram II.

A, B and C are cement mills. Each seeks business at M, a town or destination with a 50-cent freight rate from A, 55 cents from B and 60 cents from C. This gives A a 5 cents advantage over B and a 10 cents advantage over C. A figures that he can sell at a mill price of, say, $1.50 so he adds the 50 cents freight and quotes $2.00 at M. Then, if B and C want to do business at M they must meet A's price requiring B to go 5 cents below A in his mill price and C to go 10 cents below A in his mill price. Unless B and C can make the mill price sacrifices required by the market at M as made by A's price of $2.00, then A will monopolize the market at M.

In other words, as the economic law precludes a difference in prices of portland cement at the same market at the same time, the place of competition between sellers shifts from the market to the mill. Thus the usually uniform price at any market instead of indicating lack of competition really is the result of severe competition between manufacturers. The variation in price is not at the point of destination but at the mill. While all sellers quote the same delivered price, they each get different mill prices and the manufacturer farthest from the buyer's market receives the smallest mill price for his product.

These two diagrams show why the practice has grown up of selling cement f.o.b. destination rather than f.o.b. mill. On destination sales freight rates are figured by the manufacturer and included in his price. Thus the purchaser is relieved of the burden of figuring freight rates—and freight tariffs are complex problems to figure. Furthermore, if prices were quoted f.o.b. mill, each manufacturer quoting in a given market would simply learn the price quoted by the mill nearest that market, add the freight rate from that mill and thus arrive at his competitor's delivered price; then from that price he would deduct his own freight and use the result as his mill price for quotations to purchasers located in the market affected.

But how do manufacturers know what prices are being quoted at a given time at a given market by all other manufacturers? Here again the answer is simple. Every cement manufacturer advises buyers from time to time of his prices at their destinations. This is done particularly at the time of a change in the manufacturer's price by mailing literally thousands of quotations to cement buyers located all over the country. Some of the larger manufacturers also report their price changes to the newspapers. At least one engineering journal of national circulation publishes from time to time a list of prices at important cement mills.

Thus it is easy to learn the exact price of any manufacturer at any time in any market. If any manufacturer should today mail quotations to the trade, many receivers of these quotations would immediately advise other manufacturers with whom they deal. These latter manufacturers learning of such quotations at any market would simply deduct from the price so quoted, freight rates from nearby cement mills and thus learn the mill prices used by those manufacturers who had issued such quotations.

It is the normal circumstance for cement prices to be uniform at a given market at a given time. They simply could not be otherwise. No manufacturer can sell his cement at a destination price higher than that quoted by any other manufacturer. Also he knows that if he quotes a price lower than that quoted by others, the others would meet it. Thus the whole market level would be lowered. This is only another way of saying that no manufacturer can quote higher than the going market price and get any business and he fears to quote less than the market price because if he did so, the market price would be lowered.

▼

Copper Sulphate Treatment Kills Roots in Sewers

By J. W. McAMIS

Superintendent Water Works and Sewerage, Greenville, Tenn.

ROOTS give a great deal of trouble in the smaller sewers, by causing stoppages wherever they may happen to find an entrance into the pipes carrying domestic sewage.

For four or five years now we have been using copper sulphate to combat this trouble.

We have a man whose duty it is to visit each manhole in the system at least once each month, looking for stoppages. He carries along on these trips a small bag or bucket of copper sulphate crystals and drops a few of the crystals down into the flowing sewage wherever he suspects that the stoppage is likely to be down stream.

After a reasonable amount of experience in this work a man can tell pretty well where trouble is to be expected in the near future, by the nature of the flow of the sewage and by the conditions in the bottom of the manhole.

In cases where stoppage is due to roots, sewage will back up into the next manhole above during periods of greatest flow during the day and will later recede during periods of low flows. This condition may exist for days or possibly weeks before the sewage begins to overflow the top of the manhole and run into the street. By throwing in a few of the copper sulphate crystals while the sewage is still flowing, a sufficient concentration of the poison will usually reach the seat of the trouble to eliminate it before the stoppage is complete.

At Greenville, we have the same man doing this work that looks after the disposal plants and he tells me that he can predict almost exactly when the balls of roots will turn loose and come down to the treatment plant following the copper treatment.

Since we have been using this scheme it is a rare day when we have to send out a truck with sewer-rods and other equipment to open up a stopped sewer.

▼

What a Small Town Can Do

The *Ohio Health News* for Feb. 15 contains the following interesting note:

"A surplus on hand and the reduction of water rates is substantial proof that municipal utility ownership can be made profitable to a municipality when properly managed. All the expense of the new tank, $2,800, was paid from a surplus derived from water rents.—Attica, O., *Hub,* Jan. 12, 1933.

The foregoing news item shows what a small community can do. The population of Attica was 783 in 1930. The village has its own water works, consisting of a dam across Honey Creek, a water purification plant and an elevated tank on the distributing system. The purification plant is complete in every detail with chemical treatment, coagulation basins, filters and disinfection of the effluent. The plant is under the supervision of a chemist who specializes in water treatment.

Water supplied to the residents of this small village compares favorably with that of any of the cities of the state.

MECHANICAL AGITATION BY MOTOR DRIVEN PADDLES AT WINNETKA, ILL.

By CARL LEIPOLD
Superintendent Water Filtration Plant, Winnetka, Ill.

THE design and retention period for mixing basins was found and shown to be very important factors in treatment of Lake Michigan water at Winnetka.

The original plant at Winnetka of 3 M.G.D. capacity, was completed and put into operation on March 22, 1922. It had one mixing basin of the over and under baffle type having a capacity of 6,000 gallons with a nominal retention period of 3 minutes and velocities of .87 F.P.S. maximum and .29 F.P.S. minimum at plant capacity. This mixing basin showed unsatisfactory results in the forming of the alum floc during a 4-year period of operation. In May, 1926, additional baffles were installed in the first section of this mixing basin having the baffles placed in a horizontal position. This increase in velocity or violent mix at the start having velocities of 1.28 F.P.S. maximum and .58 F.P.S. minimum and a final mix having velocities of .29 F.P.S. maximum and .35 F.P.S. minimum, showed an improvement in the formation of the alum floc but still was not satisfactory for an every day operation. Chemical applications had to be eliminated for many days each year. It was decided from experiments made with a Baylis experimental mixer that added mixing was necessary.

An additional mixing basin was installed in the coagulation basin, having a capacity of 22,000 gallons with a nominal retention period of 10 minutes and velocities at the outer ends of the paddles of 2.4 F.P.S. maximum and .95 F.P.S. minimum at plant capacity. This basin was put into operation on June 19, 1928. The mixer was of the mechanical agitator type having a three H.P. varying speed, brush shifting single phase motor, a vertical drive speed reducer and two sets of paddles assembled to the vertical drive shaft. These paddles had a surface area of 8.40 sq. ft. which would give 350 cu. ft. of basin capacity per square foot of paddle surface area. The speed of the paddle was variable from 2.7 R.P.M. to 6.5 R.P.M. The KW. hour reading per 24 hours for the maximum speed was 18 and for the minimum speed was 12. Trouble was given by the motor during the 3-year period of operation, resulting in interference with experiments to determine the proper paddle speed for efficient mixing. However, the mixer indicated that this was a satisfactory method of mixing and furnished the basic design for the new plant.

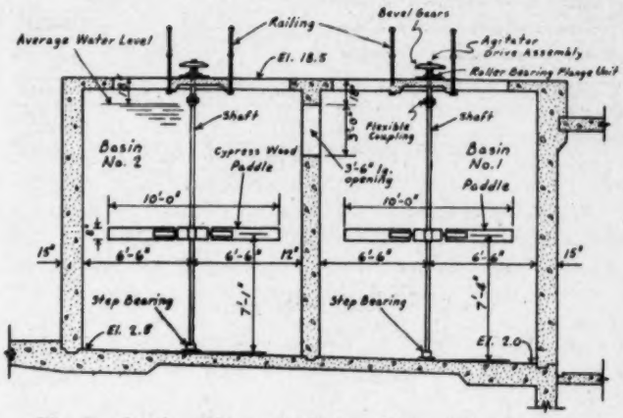


Fig. 2.—Section Through Mixing Basins, Nos. 1 and 2.

The new plant extension was completed and put into operation on Feb. 14, 1932. It has 6 mixing basins (Fig. 1) having a combined capacity of 121,000 gallons with a total nominal retention period of 30 minutes at plant capacity. The mixer (Fig. 2) is of the mechanical agitator type having a two H.P. 5-speed 3-phase motor, a horizontal drive speed reducer, one set of bevel gears and one set of paddles assembled to the vertical drive shaft. The basins are operated in parallel using 3 mixing basins with each open coagulation basin.

During the first few months of operation, tests were made to determine the proper paddle speed. It was found that the best results in mixing were given with the paddle speeds at 3.0 R.P.M. in the first mixing basin, 2.3 R.P.M. in the second mixing basin and 1.5 R.P.M. in the third mixing basin. In other words, a somewhat violent or fast speed mix to start and finishing with a gentle or slow speed mix.

The paddles in the first set of three mixing basins were adjusted to a 30 degree angle from the vertical center line and in the second set of three mixing basins the paddles were adjusted to a vertical position. After the 82-day test period, it was shown that much more

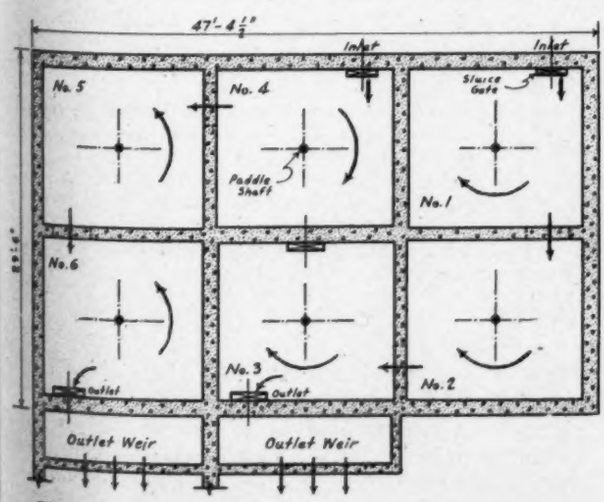
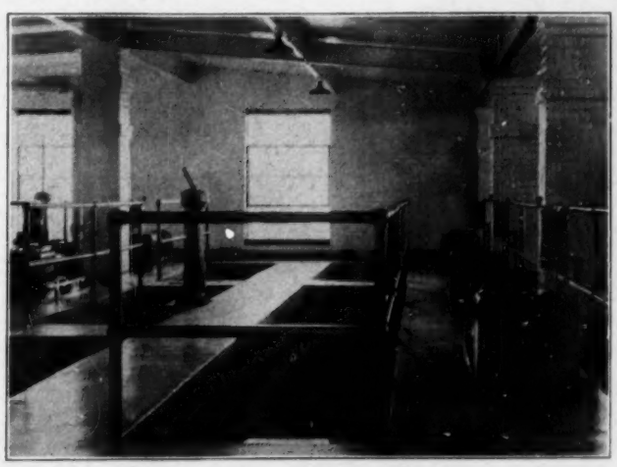


Fig. 1.—Plan of Six Mixing Chambers, Winnetka, Ill.



View Showing Arrangement of Mixing Basins at Winnetka, Ill. (Motors, Speed Reducers and Controllers on the Right)

MIXING BASINS USED -- NO.	1, 2 & 3	4, 5 & 6
DATE CLEANED	Aug. 17, 1932	Aug. 16, 1932
PREVIOUS DATE CLEANED	May 27, 1932	May 27, 1932
NUMBER OF DAYS IN SERVICE	82	81
TOTAL WATER PUMPED --- GALLONS	213,115,000	
MAXIMUM RATE OF WATER PUMPED — M.G.D.	6.8	
DAILY AVERAGE WATER PUMPED --- G.P.D.	2,600,000	
G.P.M.	1805	
DAILY AVERAGE PLANT SERVICE — HRS.	21.20	
CAPACITY OF BASINS USED — GALLONS	61,500	60,300
AVERAGE NOMINAL RETENTION PERIOD OF MIXING ------- MINUTES	68	66
PADDLE POSITION	30° Angle	Vertical

MIXING BASINS NO.	PADDLE SPEED R.P.M.	VELOCITY AT OUTER ENDS OF PADDLE F.P.S.	KW HRS. USED PER 24 HRS. PER BASIN
1 & 4	5.0	1.87	7
2 & 5	6.5	2.43	10
3 & 6	7.2	2.70	10

Paddle Surface Area ---------- 6.13 sq. ft.

Cu. Ft. Average Basin Capacity Per Sq. Ft. Paddle Surface Area ------ 448

Report of Operations of Mixing Basins Between Periods of Cleaning the Basins

sludge had settled in the last two basins of the first set of three mixing basins than in the last two basins of the second set of three mixing basins. This indicated that the mixing basins having the paddles placed in the vertical position keep the capacity and retention period of mixing at the maximum, while the mixing basins having the paddles placed at the 30 degree angle from the vertical center line, serve as a settling basin which is not practical for this type of mixer. An increase in the paddle speed is probably necessary to eliminate the sludge from the settling in these basins. This increase in paddle speed would probably delay the alum floc from increasing in size at the proper time.

The 6 new mechanical agitator mixing basins at Winnetka have shown during the 82-day test period very satisfactory results in forming an excellent alum floc with settling at the proper time. The average length of filter runs during this test period were 35.24 hours with a maximum of 72.75 hours and a minimum of 10.25 hours. The average rate of filtration was .525 M.G.D. or 1.40 gallons per square foot per minute with a maximum of 3.17 gallons per square foot per minute and a minimum of 1.05 gallons per square foot per minute.

The number of cubic feet of mixing basin capacity per square foot of paddle surface area, would probably serve as a method of comparison of mechanical agitators.

An article disclosing the results of settling during the 82-day test period using the mechanical agitator type of mixing, will follow in a later issue.

▼

New Jersey Sewage Works Association to Meet March 23rd at Trenton, N. J.

The Secretary of the New Jersey Sewage Works Association, John R. Downes, has mailed out programs of the 1933 meeting to be held in Trenton, N. J., at the Hildebrecht Hotel on March 23rd and 24th.

THE PROGRAM

THURSDAY, MARCH 23RD

Application of Sewer Rental Laws in New Jersey—C. A. MacDonald.

New Rules Covering Licenses of Plant Operators in New Jersey—J. B. Baty.

Pollution of Bathing Water as to Effect on Health—C. G. Wigley.

LUNCH

New Developments in Chemical Precipitation of Sewage—L. I. Hedgepeth.

New Developments in Chlorination of Sewage—Dr. Franz C. Schmelkes.

Chemical Precipitation in Conjunction With Sprinkling Filters—John R. Downes.

Comparison of Treatment of Fresh and Stale Sewage—Dr. Wm. Rudolfs.

Speechless Dinner* and Entertainment.

(Round Tables scheduled before and after the dinner.)

FRIDAY, MARCH 24TH

Business meeting.

Operation of the Collingswood Activated Sludge Plant—C. W. Dare.

*The "Speechless" dinner is an innovation of the New Jersey Association started three years ago by P. N. Daniels.

Operation of the New Princeton Disposal Plant—I. R. Riker.

LUNCH

Practical Data On Sprinkling Filter Operation—L. O. Lacy.

Discussion opened by H. Heukelekian.

Operation of the Freehold Plant—W. J. Schiverea.

R. F. C. Loans and Financing Sewage Disposal Works—(An open discussion).

Adjournment.

▼

Association Meetings Scheduled

Mar. 22-24—Canadian Section, A W. W. A. Hotel Chateau Laurier, Ottawa, Ont. A. E. Berry, Secretary, care of Ontario Dept. of Health, Toronto, Ont.

Mar. 23-24—New Jersey Sewage Works Association. Hotel Hildebrecht, Trenton, N. J. John R. Downes, Secretary, Bound Brook, N. J.

Apr. 4-6—Southeastern Section, A. W. W. A. Radium Springs Hotel, Albany, Ga. W. H. Weir, Secretary, Room 138, State Capitol, Atlanta, Ga.

Apr. 10-12—Florida Section, A. W. W. A. University of Florida, Gainesville, Fla. Louva G. Lenert, Secretary, State Dept. of Health, Jacksonville, Fla.

Apr. 19-20—Illinois Section, A. W. W. A. Hotel Nelson, Rockford, Ill. J. J. Doland, Secretary, University of Illinois, Urbana, Ill.

Apr. 21-22—Montana Section, A. W. W. A., to be held at Harve, Mont. Herbert B. Foote, Secretary, Director, Division of Water and Sewage, State Board of Health, Helena, Mont. In connection with the above, there will be held a two-day short school for water works operators, April 19th and 20th.

Apr. 23-28—Oklahoma Water and Sewage Conference. A. & M. College, Stillwater, Okla. H. J. Darcey, Secretary, Chief Engineer, State Health Department, Oklahoma City, Okla.

Apr. 27-28—Four States Section, A. W. W. A. Washington, D. C. (Hotel not yet selected.) C. H. Becker, Secretary-Treasurer, 400 Chestnut Street, Philadelphia, Pa.

May 1—New England Sewage Works Association. Hotel Blackstone, Woonsocket, R. I. F. W. Gilcreas, Secretary-Treasurer, care Weston and Sampson, 14 Beacon Street, Boston, Mass.

May 4-5—Maryland-Delaware Water and Sewerage Association. Baltimore, Md. A. W. Blohm, Secretary, State Dept. of Health, Baltimore, Md.

May 11-13—Pacific Northwest Section, A. W. W. A., to be held at Bellingham, Wash. Ernest C. Willard, Secretary, 720 Corbett Bldg., Portland, Ore.

June 12-16—53rd Annual Convention of the American Water Works Association. Hotel Sherman, Chicago, Ill. Secretary, B. C. Little, 29 West 39th Street, New York, N. Y.

▼

OHIO RAINFALL DEFICIENCY — The Ohio Health News of Jan. 15 states that Ohio suffered a deficiency of virtually two-thirds of a year's rain in the last three years and already is shy 1½ in. this year, which doesn't promise much for either quantity or quality of this season's water supplies.

WATER SOFTENING PLANT AT WESTERN SPRINGS, ILLINOIS

By DONALD H. MAXWELL*
Consulting Engineer, Chicago, Ill.

WESTERN SPRINGS, Illinois, began using softened water from its new municipal plant January 10, 1932. This western suburb of Chicago obtains its water supply from two wells about 375 feet deep in the Niagara limestone, which yields a very hard water for this particular locality, the total hardness being 900 parts per million. Water is now delivered to the consumers iron-free and with a total hardness of about 125 parts per million. For household use it compares favorably with filtered Lake Michigan water.

The cost of softening is approximately 22 cts. per 1,000 gallons, including fixed charges, even though the plant operates on an average but three and one-half hours a day.

Quality of Well Water

Typical analyses of the Western Springs well water are as follows:

	Analysis by Illinois Department of Health February 2, 1927	Analysis by Chas. P. Hoover June, 1930
Alkalinity	398	356
Non-carbonate hardness	531	540
Total hardness	929	896
Calcium	228	232
Magnesium	87	77
Iron as Fe	3.5	3.4
Anhydrous sulfuric acid	544	516
Chlorides as Cl	11	21
Free CO_2	...	82

These analyses show a non-carbonate hardness from 530 to 540 parts per million, which is nearly 60 per cent of the average total hardness. The high iron content, 3.5 parts per million, made the water particularly objectionable from the standpoint of staining of laundry and plumbing fixtures.

*Of Alvord, Burdick & Howson, Cons. Engrs., Chicago

Water Treatment Investigation

Prior to designing the treatment plant, experiments were made in order to select the best and most economical softening process to use. A complete model lime soda-ash softening plant was improvised, which included the following parts:

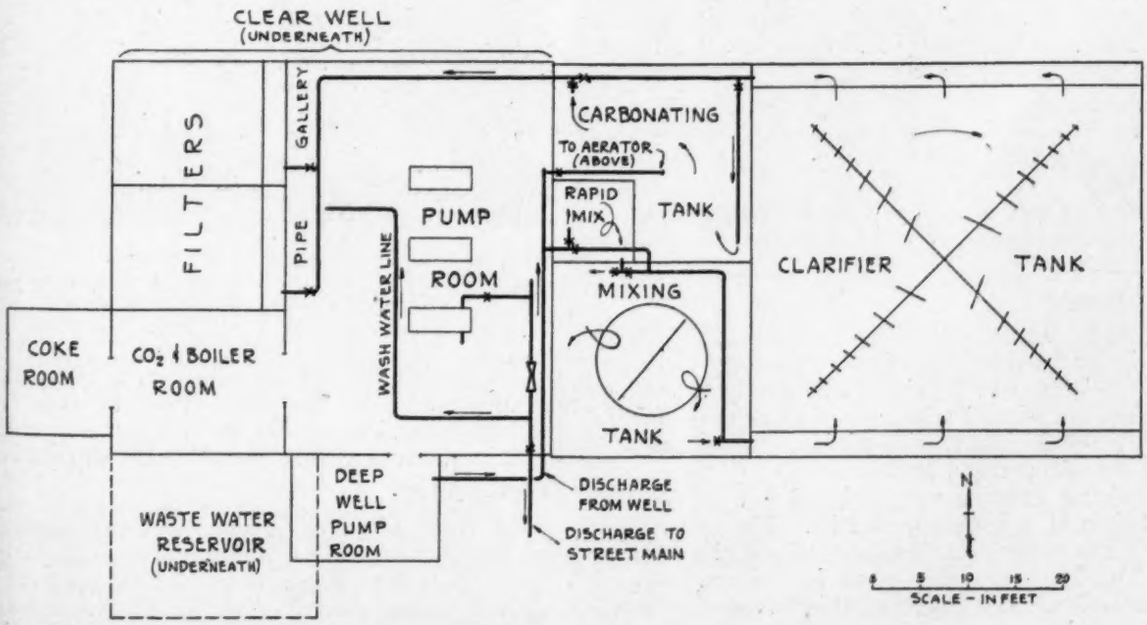
1. Aerator.
2. Constant level feed box for measuring water to softener.
3. Chemical dry feed machine.
4. Two mixing tanks, capacity 7 gallons each.
5. Two clarifiers, capacity 52 gallons each.
6. One carbonation tank, capacity 21 gallons.

The plant was arranged for sludge return to the mixing tanks. It was operated at a rate of 22 gallons per hour.

With this plant, it was demonstrated that an iron-free, good tasting, soft water could be obtained, but the apparatus for feeding chemicals and the means of control of CO_2 application were not sufficiently precise to permit of obtaining as consistent quantitative results as desirable for purpose of estimating the cost of softening. It was found necessary to resort to laboratory (bottle) experiments for precise determination of quantity of chemicals and time of settling required.

The conclusions drawn from the experimental work were as follows:

1. Thirty-one to 32 grains per gallon of quick lime and 30 grains of soda-ash would be required to produce a water having a hardness of 100 parts per million.
2. The mixing time should be 30 minutes.



Diagrammatic Plan of Water Softening Plant, Western Springs, Ill.

3. The settling period should be two hours as a minimum.

It was determined further that the water was especially well adapted to softening by the combined lime-zeolite process.

Selection of Process

Comparative estimates were made of investment required and annual cost of four types of softening plant as follows:

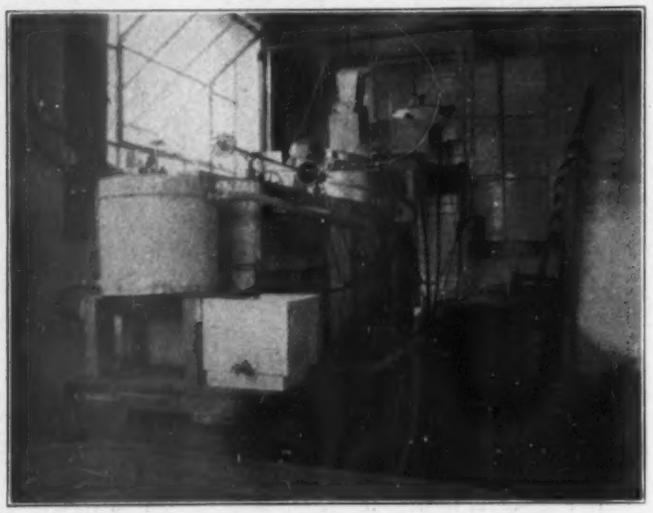


Fig. 1—Experimental Water Softening Plant, Western Springs, Ill.

	Plan "A" Lime-Soda 1 Unit	Plan "B" Lime-Soda 2 Units	Plan "C" Lime-Soda Railroad Type	Plan "D" Lime Zeolite
Investment	$80,520	$100,210	$67,100	$111,320
Annual cost — Interest and depreciation at 8%	6,450	8,000	5,620*	9,450*
Operating expenses based on year 1929	14,640	14,140	14,640	12,900
Total annual cost	$21,090	$ 22,140	$20,260	$ 22,350

*8.5 per cent.

The plans above estimated are not strictly comparable in that plan "C" does not include any soft water storage, whereas the other plans provide 140,000 gallons storage.

Plan "A" was recommended as the best suited to the conditions at Western Springs and was adopted with the following plan of operation:

(a) Aerate.
(b) Rapid mix of lime and soda-ash, 5 minutes.
(c) Slow mix, 35 minutes.
(d) Settle, 2 hours and 20 minutes.
(e) Return part of sludge to rapid mixing tank.
(f) Carbonate, 24 minutes.
(g) Filter.

Plant Design

Plant design was restricted by limitation of funds so that particular attention was given to economy and compactness of layout and provision for orderly expansion.

The plant is designed with a rated capacity of 1,500,000 gallons per 24 hours, with mixing, settling and carbonating periods as noted above.

The building exterior was designed for the location closely adjoining a residence district. The upper floor is divided into meter shop, lavatory and chemical storage room. The latter provides space for two carloads of chemicals and two feed hoppers. It is served by a monorail with outside overhang and one-half ton electric hoist.

Chemical feed equipment, part of the motor control equipment, laboratory and filters are located on the main floor, from which access is had to the aerator and mixing, settling and carbonating basins which are immediately adjoining, but outdoors.

The main switchboard, pumps and carbonating and heating installations are located at basement level, the new well pump being housed beneath the front porch. The clear well is located under the filters. The high lift pump pit and the wash water cistern are outside in the corner between the carbonating room and the well pump room.

Aeration

The aerator consists of an aer-o-mix unit mounted on a deck over the carbonating basin with fountain discharge onto a baffled circular splash plate. This device operates on about 7 feet head measured from inlet flow line to the raised splash plate and on a total head of 8½ feet to tail water under the splash plate. The equipment as first installed removed about 50 per cent of the carbon dioxide (CO_2) gas, but has been modified and is now reported to remove from 70 per cent to 72 per cent and the manufacturers hope to even further improve this performance. Payment for the unit is to be made on the basis of CO_2 removal.

From the baffled plate, the aerated water falls onto a concrete pan from which it flows to a second aer-o-mix unit utilized as a rapid mixer in connection with the rapid mix tank over which it is installed.

Chemical Feed

Lime and soda ash are fed by two automatic weighing and recording, electric motor operated dry feed machines with slakers. Each machine has a feed range of 70 to 400 pounds of chemical per hour. The machines were enclosed dust tight. The charging hoppers and slakers are vented outdoors through a spray tank and exhaust fan. The discharge from the two dry feed machines flows into a small metal tank partly submerged in the rapid mixing tank, thence to the rapid mixer.

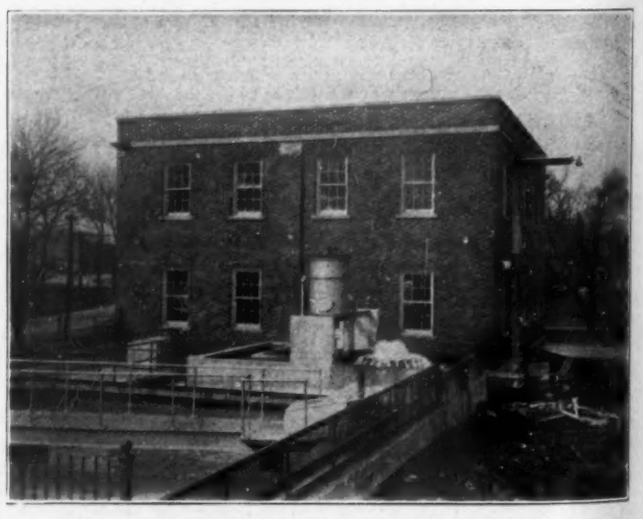


Fig. 2—New Water Softening Plant, Rear View. Right Center —Aeromix. Left Center—Slow Mixing Tank and Impeller Agitator Mechanism. Foreground—Clarifier.

Rapid Mix

The rapid mix tank is about 7½ feet square by 12 feet deep. A second aer-o-mix unit is mounted over the rapid mix tank at the outlet end of the concrete aerator pan, and utilizes about 2½ feet head. The aerated water enters this aer-o-mix and after passing through the draft

tube, where it receives the chemical solution, discharges at the top of the rapid mix tank in which it produces considerable agitation.

Slow Mix

Slow mixing (secondary mixing) is accomplished in a tank 19 feet square by 12 feet deep in which is mounted an impeller agitator. This consists of a motor driven two-vane impeller on a central vertical shaft

Fig. 3—"Aer-O-Mix" Aerator Splash Plate

terminating at about one-third depth in an upward flow concrete draft tube of 12 feet diameter. Three speeds are provided, 10, 12½, and 15 rpm. This equipment causes a radial loop flow in a vertical plane and gives a very thorough agglomeration effect without violent agitation.

Clarifier

The secondary or slow mixing tank discharges directly to the clarifier influent channel. The clarifier or settling tank is 40 feet square by about 12 feet deep, equipped with a traction clarifier. The influent trough has an adjustable metal lip to provide uniform distribution of inflow and the inlet and outlet weirs are baffled to give better vertical distribution of flow across the tank. The clarifier mechanism operates at a periphereal speed of 6¼ feet per minute.

The sludge outlet is piped to the pump room where it passes through a sight-feed from which it is discharged at will directly by gravity to the sewer or to the sludge pump for return to the mixing tank. The plant is now being operated without returning any sludge. A valve above the sight-feed permits of regulation of the rate of sludge discharge to the sewer, to avoid unnecessary waste of water.

Carbonating Basin

Carbonation takes place in an L-shaped basin 12 feet deep and about 10½ feet average width by 27 feet long, located under the aerator pan. CO_2 gas is introduced through a pipe grid placed at the tank bottom. The grid is made of ¾-inch pipe with 1/16-inch holes 6 inches centers on the under side and placed 2½ feet apart. The grid rests on top of ¾ inch sill pipes laid on the basin floor.

CO_2 Generating Plant

CO_2 gas is supplied from the stack of the coke or coal fired steam boiler used for heating the buildings. The boiler is equipped with an automatic stoker, which has been used since the plant went into operation. The abrasive action of the coke has been destructive of the screw conveyor feed, but it is understood that the manufacturers are taking steps to remedy this defect. The stoker has three speeds, 10 lb., 20 lb. and 30 lb. of fuel per hour. The slowest speed is used when the heater is run for CO_2 production only and the higher speeds for heating. The stoker provides good fuel and draft control and has been found very satisfactory in connection with CO_2 production, the installation showing results as high as 17 per cent CO_2 in the stack gas continuously when burning coke.

Automatic control of the stoker protects the boiler against low water, excess pressure and excess exit gas temperature. For winter operation, when heating the plant, the stoker feed is thermostat controlled and is pressure regulated between 2 pounds and 4 pounds steam pressure. When the plant is running but heat not required, steam is by-passed to a condenser through a regulating valve set at 3 pounds. The condenser circulating water is returned to the clear well and condensate returned to the boiler. When the plant is not operating, control of the heating boiler is regulated by an adjustable time-o-stat which is set to operate 10 minutes every hour, this having been found about right to keep the fire alive.

The gases are cooled from 500 degrees to 100 degrees F. in a built-in brick lined scrubber, the circulating water from which is delivered by a bilge pump to the wash water cistern. The cooled gases are delivered from the scrubber, against the 12 feet head on the carbonating basin grid, by a motor driven rotary compressor, which stops automatically if the CO_2 supply is shut off. A meter records the percentage of CO_2 in the gas and the pounds per hour discharged through the grid.

Filters

Two 750,000 gallons per day (rated capacity) sand filters of conventional construction are provided, but are rated at 3 gallons per square foot per minute. Valves are manually operated. The filters form one side of

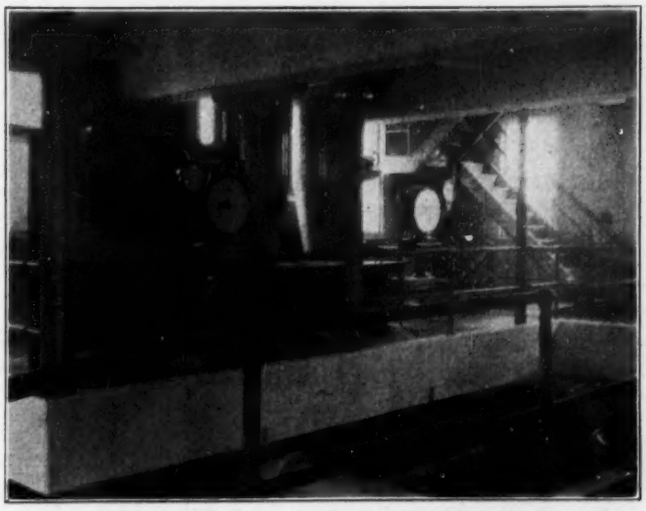


Fig. 4—Lime and Soda Ash Dry Feed Machines with Scales

the pump pit, which also serves as a pipe gallery. The wash system is designed for a 24-inch vertical rise per minute, no provision being necessary for increasing the wash rate in summer as the water temperature remains practically constant at 55 degrees. The laterals are 2-inch cast iron pipe with ⅜-inch perforations on 6-inch centers. The gravel layer, carefully graded, extends 21 inches above the center line of the laterals. Next comes a 4-inch layer of No. 2 torpedo sand, followed by 26 inches of filter sand having an effective size of 0.45 to 0.50 millimeters and a uniformity coefficient between 1.3 and 1.6.

High Lift Pumps

The three 500-gallon per minute high-lift motor driven centrifugal pumps take suction from the clear well located beneath the filters and pump pit. Each pump is connected to an overhead vacuum tank which is piped to bottom of the clear well and to a rotary vacuum pump controlled by a float switch. The main pumps are protected against failure to prime or running after emptying the clear well. Equipment is now being added to give a plant alarm when the clear well is full and an alarm at the village hall when the clear well becomes empty.

The high lift pump control is mounted on the main switchboard, of the dead front type, located in the pump

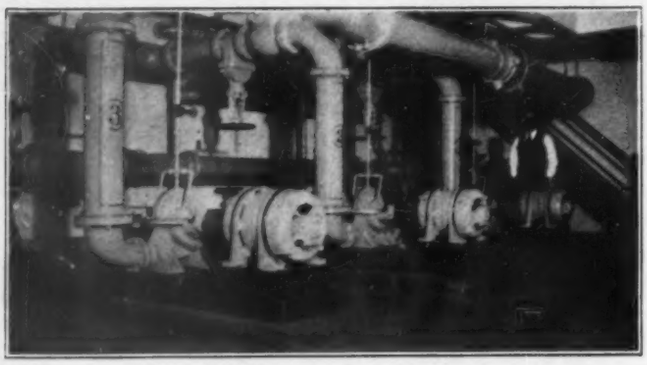


Fig. 5—High Lift Pumps at Western Springs Plant

pit. Manual and separate automatic pressure control is provided for each pump. In normal operation the last of the three pumps shut off at tank full pressure and start again after a 10-foot drop. If the draft drops the tank level another 10 feet a second pump goes into operation and finally the third pump starts at a still lower level. The pumps cut out in sequence as the tank fills. A sequence changer makes it possible to use the three pumps in any order desired.

With this arrangement ordinarily three-quarters of the elevated tank capacity is kept in reserve at all times. Any unusual draft is promptly and automatically replenished from the clear well, without the necessity of having an operator at the plant.

Unique Arrangement for Washing Filters

The same pumps are used for washing the filters, wherein a flow of 2,600 gallons per minute is required. This rate is supplied by the pumps operating against about 90 feet total head at which point their efficiency is only 5 points below the maximum.

Before washing filters, the main discharge valve to the distribution system is closed and the pumps stop. The valve to the wash water line is then opened. As the wash valve on the filter is opened slowly the pumps start up in succession automatically as the pressure drops. Upon closing the filter wash valve gradually the pumps shut off in the reverse order with rising pressure. This arrangement of washing directly from the pumps is convenient and has the advantage of not depleting the elevated storage. It slightly reduces the cost of wash water due to lower head pumped against.

Wash Water Cistern

Wash water and CO_2 scrubber circulating water is reclaimed in a cistern and repumped automatically to the rapid mixing tank by a 100 gallon per minute pump, the sludge being removed in the clarifier.

Operating Schedule

For the present, pumpage requirements are being met by running the low lift (deep well) pumps and softening plant on an average of about 4 hours per day, usually two hours morning and evening, the clear well being filled each time. Both wells are utilized, supplying sufficient water to run the plant almost exactly at rated capacity. Plant attendance is not provided during the hours of shut down, except as incidental work may require.

Better results could probably be obtained by operating the plant at about half capacity by pumping one well instead of two and operating for about twice as long each day as is the present practice. This would nearly double the reaction and settling periods and reduce the load on the filters. Sensitiveness of the aer-o-mix to change in rate and inability to handle the wide range with a single unit would probably give lower efficiency of aeration. Otherwise the plant has considerable flexibility.

Practical Benefits

It is reported that about 40 per cent of the homes in Western Springs had zeolite softeners. Others had cisterns. These facilities did not do away with the staining of fixtures and it is estimated that the annual cost of zeolite softeners and cleaning compounds for the average household was considerably in excess of the present increased cost of city water due to the necessary doubling of rates. The plant has been in operation only a few months, but there is considerable satisfaction with the results. It is stated that a single store reported a falling off in sales of "sani-flush" from 180 cans during the week before the plant started to only 14 cans in the month following.

Plant Cost

The iron removal and water softening plant cost complete (except land and new deep well and pump for same but including 150 feet of 8-inch pipe laid under railroad tracks and about 500 feet of 12-inch cast iron discharge line), a total of about $98,000 cash. This includes engineering and $2,625 interest during construction. The work was financed under the water revenue bond act of 1927, the bond issue for the improvement being $110,000.

Acknowledgment

A number of features in the plant are due to Mr. S. M. Hull, member of the Village Board of Trustees, and an industrial chemist of wide experience, who devoted much detailed attention to design, selection of equipment and construction, and who now supervises operation.

The model softening plant was loaned to the village by the Dorr Company, who also furnished the services of an operator.

The aer-o-mix aerating units were supplied by Vogt Bros. Co.; dry feed machines by the Omega Machine Co., and the impeller agitator and clarifier by the Dorr Company.

Acknowledgment is also due to Mr. G. F. Graham, village engineer, who supervised the construction, and to the Burnip Construction Company, general contractors, for the very satisfactory execution of the construction.

The plans and specifications for the plant and the preliminary report and estimates were made by the writer's firm, in co-operation with Mr. C. P. Hoover, consulting chemical engineer of Columbus, Ohio, who also supervised the preliminary investigations.

This article was drawn from a paper presented before the Illinois Section of the A. W. W. A. by the author.

THE CAUSE OF VARIATION IN THE "SOLAR CONSTANT"

By HALBERT P. GILLETTE

AN analysis of "solar constant" records discloses a marked seasonal variation that leads to the conclusion that the cause of the variation is not due to changes in the rate of emission of heat by the sun.

In his presidential address to the American Meteorological Society in 1926 Dr. Charles F. Marvin said: "All observations (as to the 'solar constant') consistently show a well-defined climatic effect in the form of a 12-month period." He also said: "The writer is compelled to emphasize the doubtful accuracy of the high values of the pure bolographic observations as published for Calama and Montezuma (Chile) up to January, 1922." Because of the questionable accuracy of the "solar constant" observations prior to 1922, the following discussion will relate only to recent records that are regarded as being reliable.

In "Weather Dominated by Solar Changes"[1] Dr. C. G. Abbot gives a table of mean "solar constant" values at northern Chilean stations from July, 1918, to December, 1930. He says: "The best values are those obtained since January, 1924." Accordingly I have calculated the mean values by months for the seven years 1924-30 at Montezuma, which are as follows, expressed in calories per sq. cm. per minute:

January	1.9397
February	1.9390
March	1.9401
April	1.9414
May	1.9444
June	1.9450
July	1.9440
August	1.9404
September	1.9391
October	1.9389
November	1.9394
December	1.9391

The seasonal nature of the variation of the "solar constant" is clearly brought out in Fig. 1. Comparison of the curve in Fig. 1 with the precipitation curve in Fig. 2 shows that the "solar constant" in northern Chile has the same cycle as the precipitation in northern Chile. This is to be expected if there is no real variation in the heat radiated by the sun, and if an apparent variation occurs because cyclonic "holes" in the atmosphere permit more solar energy to reach the earth during cyclonic seasons. A precipitation curve is usually approximately parallel with a curve of cyclonic frequency. Hence the precipitation curve in Fig. 2 should show as nearly the same seasonal cycle as is shown in the "solar constant" curve in Fig. 1; and it does.

In this connection it is well to recall that Dr. Robert A. Millikan in 1930 found that his delicate cosmic-ray electroscope shows variations that he attributes to "holes" in the air. He regards these atmospheric "holes" as being the analogs of the great solar whirls called sun-spots. He says: "The cosmic ray electroscope is a simpler and more fundamental instrument than the barometer, and I expect it to be of aid in bringing about advances in weather forecasting and ultimately to find a place in meteorological stations. The air is simply an absorbing blanket interposed between us and a constant source of radiation coming into the earth uniformly from all directions (i. e., cosmic rays), and every eruption, or wave, or ripple in that blanket is accurately reflected by this cosmic ray electroscope."[2]

Apparently the Langley bolometer used in solar radiation measurements varies in its readings much as does the Millikan electroscope, because of variation in the number and size of the cyclonic "holes" in the air. Also it seems likely that the electrons in these cyclonic whirls tend to condense into whirl-belts, forming a sort of hollow cylinder or cylindrical shell of electrons.

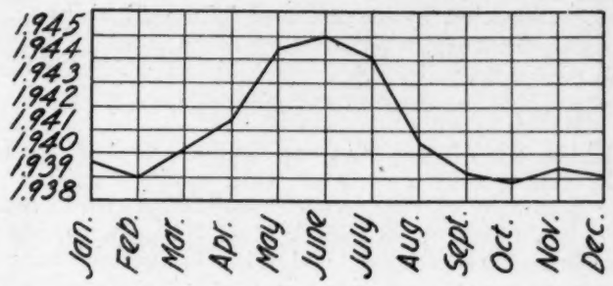


Fig. 1—Seasonal Cycle of the "Solar Constant" in Northern Chile (Calories per Sq. Cm. per Minute)

Such condensations would be favorable to the freer entrance of radiant waves from the sun or from any source of radiant energy, for electron shells partly reflect electromagnetic waves.

In "The Atmosphere and the Sun"[3] H. Helm Clayton presents analyses that show marked correlations between variations in the "solar constants" and air pressures. In common with Dr. Abbot he infers, as the

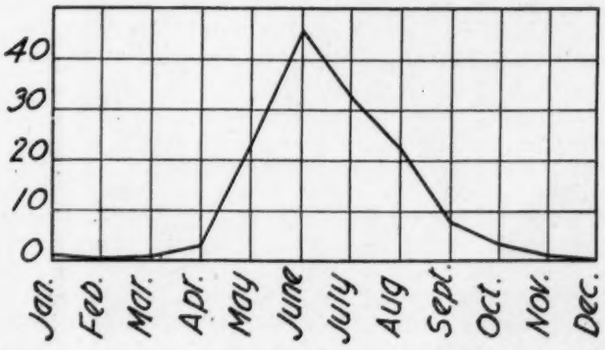


Fig. 2—Seasonal Cycle of Precipitation at La Serena, Chile (In Millimeters)

latter puts it, that "Major changes in the weather are due to short period changes in the sun." But if my interpretation of the phenomenon is correct, there is another explanation. I believe that the same planetary magnetic forces that periodically cause "holes" or sunspots in the sun's atmosphere, cause similar "holes" in the earth's atmosphere. Hence the correlations adduced by Clayton and Abbot in support of their theory, furnish equally strong support for my electron-shell theory of weather and sunspot cycles.

REFERENCES

[1]Weather Dominated by Solar Changes, by C. G. Abbot, Smithsonian Miscellaneous Collection, Vol. 85, No. 1, Feb. 5, 1931. Pub. by The Smithsonian Institution, Washington, D. C.

[2]*Engineering and Contracting*, Dec., 1930, p. 443.

[3]The Atmosphere and the Sun, by H. Helm Clayton, Smithsonian Miscellaneous Col., Vol. 82, No. 7, June 9, 1930.

EDITORIALS

WE FAVOR:

1. No diversion of water works revenues.
2. Laws permitting a city to issue "revenue bonds" for water works or sewerage improvements.
3. The passage of a "sewer rental law" in every State similar to that in Michigan.
4. Universal metering.
5. Universal treatment of water to secure not merely elimination of harmful bacteria, but freedom from hardness, odors and bad tastes.
6. Cessation of stream and lake pollution.
7. The pension system for municipal employees.
8. Registration or licensing of engineers and operators responsible for design, the approval of design, or the operation of water works, sewerage, and treatment works on either system.
9. Periodic employment of consulting engineers to diagnose any economic troubles and prescribe the cures.
10. Elimination of "politics" from the construction and operation of water works and sewer systems.

Copper

THE use of copper in one form or another is constantly on the increase in water works practice, and too, seemingly deserves more consideration also in sewage treatment and disposal. Most corrosion resistant metals such as "Everdur" and "Monel" metal are copper containing alloys. Copper is now also alloyed with aluminum for use at water and sewage treatment works where corrosion is of consequence, or where a light weight metal is desirable in plant construction or equipment manufacture.

Copper pipe and tubing has come to be considered as one of it, if not *the*, outstanding material for use in making connections between the city water main and the consumers' piping. There are several reasons why services of copper are receiving the consideration which this material deserves. Its resistance to corrosion is not the least of the reasons: Reduced costs of installing services of copper, the workability of the newer copper tubing, the elimination of lead goose-necks, and the reduction of trench and pavement cutting to a minimum are other important reasons for the popularity of copper services for new or replacement work.

Not alone has the corrosive action of the water been good reason for favoring copper piping for house connections. Frequently soil corrosion which attacks from the outside is more serious than internal corrosion. Elsewhere in this issue there is recounted the experience of El Paso, Texas, with the latter difficulty, which has only been overcome through the substitution of copper services for other materials of limited life under the soil conditions prevalent. Looking ahead, this city is purchasing copper service piping, on the lowest copper market in years, sufficient for its needs for some time in the future.

Other cities can profit from El Paso's example and at the same time an immediate replacement program will provide work for the unemployed and eventual profits for the water department. One could hardly find a better use for available funds or a more "self liquidating" type of project for which R. F. C. loans should be readily procurable.

Copper in the form of the sulphate has for generations been a boon to water works men as a material for combating algae growth in reservoirs. An unfounded fear of copper poisoning has stood in the way of more extended or more frequent use of this valuable algacide. It has been but recently revealed that the presence of copper in water is not the matter of serious consequence that it was formerly thought to be. This revelation has done much to allay the fears of copper users and now the "coppering" of reservoirs can be done with less caution and more frequently than was previously considered advisable.

A new use for copper sulphate in connection with sewage disposal has come to light in a brief article from Greenville, Tenn., which appears in this issue. "Ingrowing" tree roots in sewers, creating reduced capacities if not actual clogging of sewers, has long been a problem in sewer maintenance. The usual procedure of elimination of roots has been the laborious use of sewer cleaning and root cutting equipment in the affected areas. Now we learn from experiences at Greenville that copper sulphate added at intervals to manholes in such areas will kill the tender roots, causing them to break away and be carried out of the sewers. Furthermore, refinement of the chemical application is not a requirement and inasmuch as no damage can be done by the treatment, other than a possible wastage of chemical, what could be more simple or more labor saving than the use of this copper treatment.

Copper salts, used in conjunction with other chemicals, appear to be highly effective coagulants in a chemical precipitation process now under development for treatment of industrial wastes and sewage. Heretofore the use of copper sulphate as a coagulant has been prohibitively costly in comparison with less expensive metallic coagulants commonly employed, whereas the existing low price of copper renders the use of its salts far more attractive than in the past.

At the Baltimore, Md., sewage treatment works copper chloride (CuCl) was produced by passing chlorine water upward through a tower filler with scrap copper. The scheme proved to be practical. Per pound of copper involved the overall cost of the copper, plus the chlorine required, proved more attractive than that of an equivalent amount of copper purchasable in the form of the sulphate. Chloride of copper, considered as being a more deadly salt to organism (bacteria and algae) than the sulphate, lent an added interest to the tower chlorinating process. The control of the copper dosage was attained through maintaining at all times an appreciable surplus of copper scrap in the tower and regulation of the chlorine feed alone.

At prices now prevailing the use of copper and its salts in water works and sewerage practice, and in the treatment of sewage and industrial wastes, should engage the increasing interest of works managers, engineers and chemists.

L. H. Enslow

NEW EQUIPMENT AND MATERIALS

New Attachment for Hellige Pocket Comparator

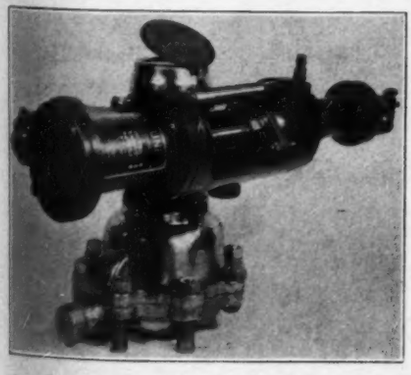
Numerous users of The Hellige Pocket Comparator who prefer this model because of its handy size and portability have expressed a desire for a device for bringing the color fields into juxtaposition so that readings with this small apparatus can be made with the convenience heretofore afforded only by the larger, more expensive standard model.

The new prism attachment now offered by Hellige, Inc., 179 East 87th street, New York, answers this need ideally: It brings the colors together into one field; it is small in size and easy to carry, so that the main feature of the pocket comparator model, its small size and convenient portability is entirely retained.

The prism attachment consists of a flat metal holder which is permanently screwed to the front cover of the comparator and into which slides the prism housing with the optically ground and polished glass prism. The prism housing, only 1½x1½x1½ inches in size, can instantly be removed and carried separately in the pocket if desired.

Builders Iron Foundry Offers Automatic Proportioning Pump for Feeding Chemicals

The illustration above is that of a newly designed device recently announced by "Proportioneers," Chicago, for controlling injection of accurate composite samples of liquids. Every proportional processing problem of the fluid industries can be simplified or improved by this automatic feeder. The device is called Tret-O-Unit. The



An Automatically Operated "Tret-O-Unit," in This Instance Motivated by a Buffalo-Niagara Water Meter

operation of this proportioning pump is controlled by rate of flow of untreated fluid, the mechanism responding to the changing throughout of the line to which it is attached. The pump injections are frequent and in direct ratio to the quantity of fluid being treated. Ratios from a few parts per million up to normal reagent percentages may be handled with equal facility.

Since Tret-O-Unit can be controlled by any existing flow-responsive device such as an ordinary water meter, a venturi meter or a rotor, or a reciprocating fluid pump, it offers a means of handling the highly specialized problems of water conditioning; feeding prepared compounds; lime or soda ash solution; sodium aluminate; ferric-chloride, etc.; chlorinating or the sampling of fluids automatically.

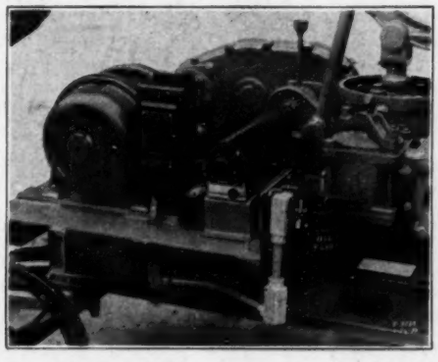
The reagent is in contact with no part of the device except cylinder and plunger, which can be furnished in a wide range of sizes and materials to resist the actions of reagents handled. For highly corrosive or abrasive fluids diaphragms are substituted for plungers.

Printed matter on Tret-O-Unit, Tret-O-Rotor or Tret-O-Motor is available by addressing "Proportioneers," 727 N. Michigan Blvd., Chicago, or Builders Iron Foundry, Providence, R. I., who are now manufacturing and distributing this equipment.

New booklets describing the above units has just been prepared for distribution.

Novel Electrical Control Applied to Portable Sludge Pump

To meet the unusual need of a large municipality for operating a portable sludge pump in outdoor service on either 220 or 440 volt electric current, the Chain Belt Co., Milwaukee, Wis., have made a unique



Portable Rex Sludge Pump, Showing Motor and Control Accessories with Housing Removed

application of electrical controls to one of their Rex Sludge Pumps. Merely turning one handle provides proper connection with overload protection for either voltage.

Three control units are used, a drum switch for proper reconnection of the motor leads, an overload circuit breaking switch, and an oil-immersed safety power switch.

The motor has speed reduction gears built integrally with it and further reduction is secured in another fully enclosed oil retaining gear case.

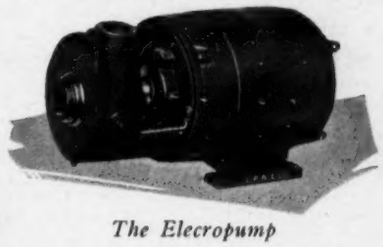
Destructive side wall thrust is eliminated by means of walking beam design; and efficient cylinder lubrication is secured through Rex "Sealed-in-Oil" plunger construction. These two features of design are responsible for the unusually long life of packing in Rex Sludge Pumps. Another novel feature of design is the Rex Horizontal Flap Valves. These allow the full 4-in. diameter opening through the valve without obstruction, resulting in the passage of large solids without the clogging experienced in valves of other types.

Similar portable plunger sludge pumps are also available in single plunger design as well as models for permanent installation with either electric motor or gasoline engine drive.

New Centrifugal Pump

A new centrifugal pumping unit for small and moderate capacities for operation against heads up to 150 ft. or 65 lbs. pressure in a single stage unit, and twice the head or pressure when furnished with two stage unit in series, has been brought out by the Lawrence Pump & Engine Co., Lawrence, Mass.

The unit consists of a single stage, single suction, fully bronze fitted (standard construction) pump with close-coupled motor. The impeller is of the enclosed type and is mounted, keyed and locked on the extension of the motor shaft. Impeller is carefully finished throughout and accurately balanced. Pump casing is of the volute type and is regularly made of close grained cast iron, but is also furnished when specified of nickel-iron, bronze, monel metal and other suitable alloys. The



The Elecropump

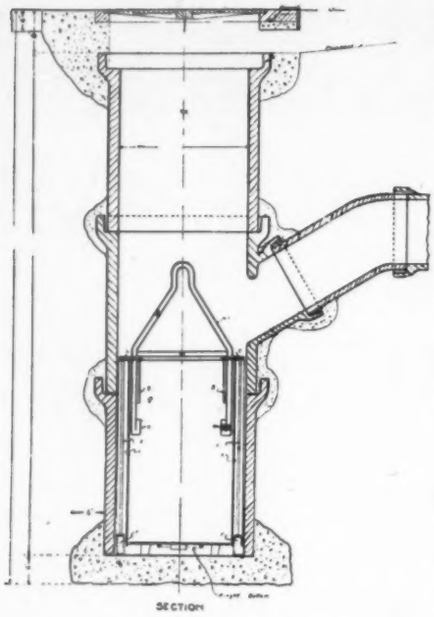
volute and frame are made with counterbored fit, which prevents any misalignment of the unit.

Stud bolts in the pump casing are accurately spaced to allow the discharge nozzle to be placed in any one of four positions of 90 degrees each. Discharge and suction nozzles on 1-in. and 1½-in. pumps are tapped for standard pipe. The 2-in. pump is provided with standard flanged connections, drilled to 125-lb. American standard.

The ball bearing motor and pump are built into one unit, and the number of rotating parts are reduced to a minimum. Couplings are eliminated and special foundation not required. This construction makes a self-contained, light in weight, easily portable unit requiring small space and can be operated equally well in vertical, horizontal or inclined position.

Catch Basin Bucket

A bucket for speedily removing street refuse directly from the catch basin to the dump truck is illustrated. The idea of putting a bucket in a catch basin is not new, but in the case of this bucket,



The Monarch Bucket

the difficulty or getting it out has been overcome by a novel device for which a patent is pending. A pair of plungers operate so as to break the bottom vacuum or mud seal as soon as a lift is exerted on the bail. It is stated that in one demonstration a dynamometer dial in the hoisting line showed that the maximum pull was 1400 lbs. for a bucket with load weighing 1100 pounds.

The Monarch Catch Basin Co., Dime Bank Bldg., Detroit, Mich., is the manufacturer. The present standard size has a diameter of 23½ ins. and a capacity of 9 cu. ft., which seems to meet the usual requirements. Of course, other sizes can be furnished as desired.

▼

WITH THE MANUFACTURERS

Eibell Leaves Worthington

Mr. F. C. Eibell, who for the past four years has been manager of the advertising and publicity department of the Worthington Pump and Machinery Corporation, New York, N. Y., has resigned. He brought to Worthington a well-rounded advertising, merchandising, sales promotion and publicity experience. He has had executive assignments on the staffs of three advertising agencies, two publishers and three manufacturers' advertising departments. His work during the past four years marked Worthington as one of the outstanding industrial advertising accounts. No announcement has been made concerning his future plans.

▼

Special Grant for Research in Water Chemistry at University of Florida

The Calco Chemical Company of Bound Brook, N. J. has established a grant to the University of Florida at Gainesville, to be devoted to research in water chemistry. The grant has been awarded to Mr. W. E. Sansbury, graduate student in chemistry who will continue a study begun during the past year under the direction of Professor A. P. Black, head of the Department of Chemistry of that institution, on the use of ferric salts as coagulants.

▼

De Celle Made Chairman of E. A. A. Program Committee

O. A. DeCelle, vice-president of International Filter Company of Chicago, has recently been made chairman of the program committee of the Engineering Advertisers' Association.

▼

A Valve Repair Demonstration

This photograph was taken during a demonstration before the Maine Water Utilities Association meeting at Portland, Me.

The Kennedy safetop hydrant installed on a main carrying 80 lbs. pressure was intentionally broken off by a heavy truck. At the impact the breakable safety section, a patented feature, parted cleanly and there was no loss of water whatever. The top part of the hydrant was undamaged and the inlet valve was being snugly against its seat without leakage, requiring no shut off of water pressure during repairs. A man working with standard tools replaced the broken safety section with a new one. The only other part required was a stem coupling with pins. In spite of the bitter day the job was completed in 26 minutes without need for excavating or water shut off. After repairs the hydrant functioned perfectly.

Hydrant Intentionally Broken Off by Truck in Demonstration Test

▼

Bailey Meter Co. Issues Bulletin Descriptive of New Fluid Meters

An attractive 24-page bulletin, describing the new line of Bailey Fluid Meters now available, has been published by the Bailey Meter Company, Cleveland, Ohio.

This bulletin describes and illustrates the several types of meters which can be furnished, pointing out the many destinctive features of the new line of meters. Other sections of the bulletin deal with the application and methods of installation of the equipment.

Numerous illustrations are included in the bulletin, comprising detailed drawings, diagrammatic sketches, equipment photographs, installation photographs, and chart reproductions in four colors.

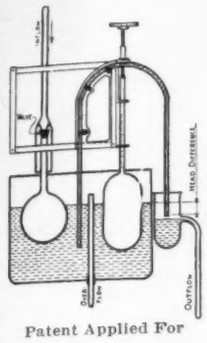
Write the Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, Ohio, for Bulletin 300.

▼

Cleveland's New Sewage Treatment Works Requires 64 Venturi Meters

The illustration shows some of the Venturi tube sections for measuring sewage, sludge and air at the Easterly Sewage Treatment Works of Cleveland, O., now under construction. Tubes for this project total 64 and range in size from 8 to 72 in. They were supplied by the Bailey Meter Co. of Cleveland, O. George B. Gascoigne, of Cleveland, is consulting engineer on this project.

Venturi Tube Sections for Cleveland Sewage Treatment Works



Patent Applied For

Will Feed the Most Corrosive Chemicals

The Phipps & Bird Solution Feeder provides the ideal answer to the demand for a solution feeding apparatus with an accurate and constant feed, that is not effected by corrosive substances, that is easy to install and simple to operate, and that is economical both in initial and operating costs.

Let us send you detailed information regarding this new feeder. Whether your plant is large or small or only for experimental purposes, you will find it a most efficient apparatus for your requirements.

PHIPPS & BIRD, Inc.

140 Virginia Street
RICHMOND, VIRGINIA

THE NATIONAL METHOD
of Water Main Cleaning

20 Years Experience

Write for Booklet
"The Cleaning of Water Mains"

National Water Main Cleaning Co.
32 Church St. New York

---

pH AND CHLORINE CONTROL

ONLY GLASS STANDARDS *are always* ACCURATE

Noted authorities and all leading firms of the water supply field are using the Hellige non-fading, and, therefore, permanently reliable, glass standards and handy Hellige Comparators as they offer exclusive features and unequalled advantages. More than 500,000 standards now in use. Approved and highly recommended. One apparatus for chlorine, pH control, and many other popular tests. Complete $15.00 and up.

Write today for detailed information.

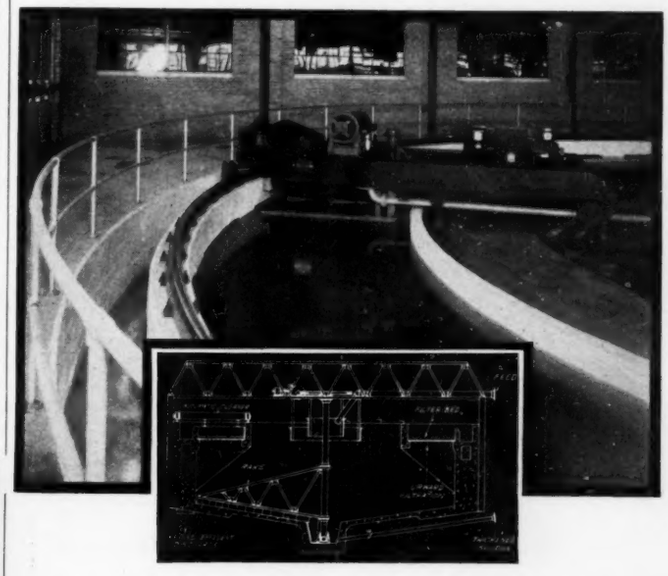
HELLIGE, INC.

179 EAST 87th STREET, NEW YORK, N.Y. U.S.A.

FILTRATION EQUIPMENT CORPORATION

LAUGHLIN CLARIFYING TANK

For the Better Removal of Suspended Solids from Sewage and Industrial Wastes



—Permits of usual sedimentation and thickening operations within a tank, at high capacity for a given tank size.

—Removes solids by positive filtration.

—Filter bed embraces entire circumference of tank, extending inwardly five feet or more.

—Operated with a traveling magnet which cleans the filter bed as necessary.

—Tanks of round or rectangular type for any capacity.

—Low power and low operating cost.

FILTRATION EQUIPMENT CORPORATION

350 MADISON AVE. NEW YORK

ENGINEER—Recently Professor of Engineering in a southern technical school; 7 years' experience in manufacture, inspection and installation of cast iron pipe; 5 years' experience in geological work, well-drilling, etc. Experience covers pipe-line design, hydraulic and sewerage calculations, survey and construction of pipe-lines, pump-house equipment, water supply conditions east of the Rockies from geologic and use standpoints. Address "G. H.," % Water Works and Sewerage, 400 W. Madison St., Chicago, Ill.

CIVIL AND SANITARY ENGINEER—Registered; B. S. in civil engineering; over 22 years' experience with the investigation, design, actual construction, purchase and installation of equipment, appraisal, estimating and operation of water supplies, filtration plants and sewage disposal works. The last eight years' work includes the design, construction and operation of sanitary works in Europe. References and details of experience may be had upon request. Age 45. Address "L. A. G.," % Water Works and Sewerage, 420 Lexington Ave., New York City.

REGISTERED CIVIL ENGINEER—Executive, having been for eight years in sanitary and municipal work, including four years as city manager. Latin-American experience investigating water supplies. Executive experience in management. Now serving as executive director of a technical relief organization. Member of the A. W. W. A., Assoc. Member of the A. S. C. E. and author of a number of technical articles. Address "J. F. P.," % Water Works and Sewerage, 420 Lexington Ave., New York City.

WATER WORKS SUPERVISING CHEMIST desires position as chemist in charge or superintendent of water works. Nine years' experience in the treatment and conditioning of water for human consumption and commercial use. Has had experience with water softening and the control of boiler feed water. Graduate chemist. Age 31. Married. Location immaterial. Salary secondary to position with a future. Address "J. F. S.," care of Water Works and Sewerage, 420 Lexington Ave., New York City.

POSITIONS WANTED

This department has been started as a service to those in the Water Works and Sewerage Fields. We hope they will make use of it. The notices are inserted without charge.

CIVIL ENGINEER — 28, technically educated, with nine (9) years of practical experience, five (5) in municipal and federal water works construction. Desires to make connection in or around New York City. Reply to "W. F. S.," % Water Works and Sewerage, 420 Lexington Ave., New York.

CHEMICAL ENGINEER AND CHEMIST with eleven years' experience in water purification and water softening, also registered professional engineer of New York state with operating, laboratory and specification experience covering municipal water supplies, boiler feed water treatment and swimming pools. Permanent or temporary position desired. Address "C. E. A.," % Water Works and Sewerage, 420 Lexington Ave., New York City.

FILTER PLANT CHEMIST—Position desired as superintendent, chemist or operator in a water purification plant. I have had five years' experience as a chemist in a large filter plant and have had four years' work as superintendent of a small plant. Holder of state license. Would be able to combine operating and laboratory work if necessary. Address "N. T. E.," Water Works and Sewerage, 400 W. Madison St., Chicago, Ill.

SUPERINTENDENT OF PURIFICATION or control chemist, or a combination of the two, in a small or medium sized plant. Technically educated in hydraulic water supply, water purification, water softening and chemistry. Will contract the operation and supervision of a small or medium sized plant. Employed at present and for the past eight years as superintendent and control chemist of small plant. Address Box 3000, % Water Works and Sewerage, 400 W. Madison St., Chicago, Ill.

CONSTRUCTION ENGINEER — Twenty years' experience in water purification and sewage disposal, the last ten having been spent in the field with broad experience on both small and extra large jobs as resident engineer or superintendent for contractors. Desire position with either consulting engineer or contractor who go after big jobs. Location immaterial, but salary a consideration. Address "E. B. A.," % Water Works and Sewerage, 400 W. Madison St., Chicago.

ARTESIAN WELLS—Engineer specializing in the construction and development of sub-surface water supply resources desires an engagement to supervise operations of this character. Have knowledge of all modern drilling methods; also extensive experience with projects of major importance, both domestic and foreign; location immaterial. References submitted on request. Address "M. S. J.," % Water Works and Sewerage, 420 Lexington Ave., New York City.

SANITARY CHEMIST—Twelve years' experience in operation of large and small sewage treatment plants. Experienced in water purification, boiler feed water treatment, also treatment of industrial wastes and stream pollution investigations. For nine years chemist in charge of sewage treatment in city of more than 300,000 population. Permanent or temporary position desired. Address "W. R.," % Water Works and Sewerage, 420 Lexington Ave., New York City.

GRADUATE CIVIL ENGINEER with extensive field and office experience; special training in estimating. Particularly experienced in pipe installations of all sorts, including gas, water and sewerage. Wishes position with city manager or engineer. Location immaterial. Box 60, % Water Works and Sewerage, 400 W. Madison St., Chicago, Ill.

EXPERIENCED DESIGNER on water works and sewerage. Have been with some of the country's leading sanitary engineering firms. Age 37; married; Assoc. Member A. S. C. E. and Member of A. W. W. A. Have been in responsible charge of design. Address "P. M. V.," % Water Works and Sewerage, 400 W. Madison St., Chicago, Ill.

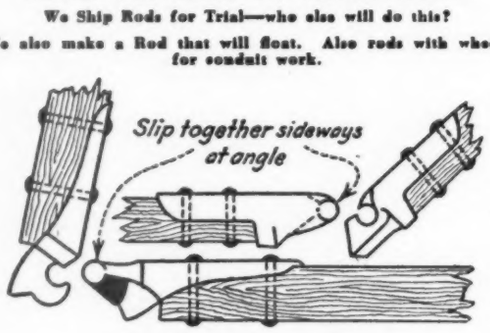
STEWART SEWER CLEANING MACHINE

Water Cleaning System, if you wish it, or Drag Bucket type.

WE WILL PAY FREIGHT AND CHARGE TO BILL.

We Ship Rods for Trial—who else will do this?

We also make a Rod that will float. Also rods with wheels for conduit work.



SEWER AND CONDUIT RODS

No Deep Shoulder Cut for Couplings. Rods retain full size and strength.

Investigate our JUMBO ROD

W. H. STEWART

1614 Locust Street . . . . . ST. LOUIS, MO.
129 George Street . . . . . BOSTON, MASS.
Box 581 . . . . . JACKSONVILLE, FLA.

CANADA FACTORY, WALKERVILLE, ONT.
Therefore No Duty for Purchaser to Pay

PACIFIC COAST DELIVERIES MADE FROM SAN FRANCISCO

The

BELLEVUE STRATFORD

Claude H. Bennett, General Manager

For two generations it has represented the highest expression of Philadelphia's famed hospitality. . . Yet—constantly advancing to meet changing conditions—it stands today as a model of what the modern hotel should be in appointments and service. . . You will appreciate its fine environment—and its rates which are consistent with the times.

IN PHILADELPHIA

Cast Iron Pipe

Bell and Spigot type
Sand Cast
Long Lengths

McWane Precalked Joints or Open Bell
Sizes: 1¼ thru 12 inches. Fittings.

McWANE CAST IRON PIPE CO. BIRMINGHAM ALABAMA

PACIFIC STATES CAST IRON PIPE CO. PROVO, UTAH

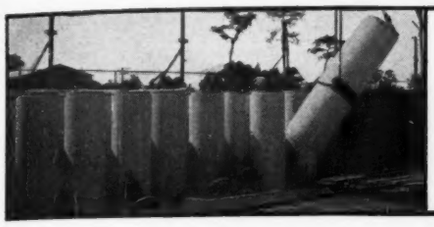
New York Chicago Kansas City Los Angeles
San Francisco Denver Portland, Ore. Dallas
Salt Lake City

ROBERTS
FILTER MANUFACTURING CO.
607 Columbia Ave., Darby, Penna.

Manufacturers of Pressure and Gravity Type Water Filters and Specialties for Water Purification and Sewage Treatment Plants.

We contract for complete installation of mechanical and hydraulic equipment in all forms of Water Filtration Plants, Sewage Disposal Plants and Pumping Stations.

Write us concerning your Sanitary Problems.



LOCK JOINT
Reinforced Concrete Pipe

PRESSURE - SEWER - CULVERT
Lock-Joint Pipe Co., Ampere, N. J.

STREET, SEWER AND WATER CASTINGS

Made of wear-resisting chilled iron in various styles, sizes and weights.

Write for Catalog and Prices

SOUTH BEND FOUNDRY CO.

All Kinds of Gray Iron Castings SOUTH BEND, INDIANA

Filtration Oil Bound Water Paint

SAND--LINDEX

Specification Grade Bulk or Bags

—Powder Form— One coat covers Black. Not affected by fumes of Sulphur, Lime, Chlorine.

Mines and Mills: Ottawa, Illinois

TAMMS SILICA CO. Chicago

228 N. La Salle St., Chicago

Answers 6,000 Questions About Excavation Costs and Methods.....

Flexibly bound in cloth, liberally illustrated, 1346 pages and 22 chapters.

Hours of cudgeling your brains, and reams of scratch paper are saved by this standard reference work, "Earthwork and Its Costs" by H. P. Gillette. The one specific branch of construction work described by this title is covered, entirely separate from all others, and analyzed to bed rock. Comprehensive reliable tables save whole days out of a year in figuring and studying. Many methods are weighed and are presented so that you can choose the one best for each job.

This book will not tell your fortune—nor make it—but it will answer all your questions about earthwork and its costs—and it will save many times its price in economizing your time. *Send for it today, receive it in a few days, pay the postman $6, study it 10 days. If, then, you decide not to add it to your library, simply mail it back to the publishers. Your money will reach you in a few days, cheerfully returned, without any red tape.*

GILLETTE PUBLISHING CO.
400 W. Madison St., Chicago, Ill.

Liquidating

NEW CAST IRON PIPE

All Sizes Bell and Spigot—Flange and Universal
New Pratt & Cady 14″ and 16″ Values
New Hydrants—A. P. Smith and R. D. Wood
Rails, Spikes, Nails and Castings
Beams, Wire Cable and Miscellaneous Equipment

AT A SACRIFICE

ACORN IRON AND METAL CO.
Tennessee and Mediterranean Ave.
ATLANTIC CITY, N. J.

CLEARING HOUSE

20% off—Rebuilt Transits and Levels
Best selection in United States. Every Instrument overhauled in our own factory. Sold subject to field test. Convenient payment plan. Your old instrument taken in trade. Write for our list (WSC73).

WARREN-KNIGHT CO.
Makers of Sterling Transits and Levels
136 N. 12th Street Phila. Pa.

Copies of the February, 1933, issue of Water Works and Sewerage are needed. Any subscriber supplying one will have his subscription extended for two months.

DIRECTORY OF ENGINEERS

Aerial Mapping Since 1922

ABRAMS AERIAL SURVEY CORP.

Contractor to Federal, State, County and Municipal Government Depts., Large Corporations—Private and Industrial Interests

WE HAVE MAPPED FROM THE AIR 61 MUNICIPALITIES
AN ENGINEERING SERVICE CONTOURED AERIAL SURVEY MAPS
Highways, Transmission Lines, Pipe Lines, City Zoning and Tax Maps, Timber Cruises.

Send for our Folder—"The Third Dimension in Aerial Photography"
Submit Projects for Contract Prices Lansing, Michigan

Alvord, Burdick & Howson

Engineers

John W. Alvord, Charles B. Burdick, Louis R. Howson. Donald H. Maxwell.
Water Works, Water Purification, Flood Relief, Sewerage, Sewage Disposal, Drainage, Appraisals, Power Generation.
Civic Opera Building, Chicago.

Black & Veatch

Consulting Engineers

Sewerage, Sewage Disposal, Water Supply, Water Purification, Electric Lighting Power Plants, Valuations, Special Investigations, Reports and Laboratory.
E. B. Black, N. T. Veatch, Jr.
Kansas City, Mo., Mutual Bldg

H. Burdett Cleveland

Consulting Sanitary Engineer

Water Supply and Purification, Sewerage and Sewage Disposal, Refuse Disposal, Treatment of Industrial Wastes, Design, Reports, Consultation, Investigation, Evaluation of Works, Supervision of Construction.
Transportation Building.
225 Broadway, New York.

Burns & McDonnell Engineering Co.

McDonnell-Smith-Baldwin-Lambert

Consulting Engineers

Waterworks Sewerage
Lighting Appraisals
Rate Investigations
Kansas City, Mo., Interstate Bldg.
Los Angeles, Cal., Western Pacific Building.

The J. N. Chester Engrs.

J. N. Chester
J. F. La Boon
D. E. Davis
J. T. Campbell
E. B. Bankson
Consulting Hydraulic, Sanitary and Valuation Engineers.
Pittsburgh, Pa., Clark Bldg

Chicago Testing Laboratory, Inc.

and affiliated
Chicago Paving Laboratory, Inc.

Consulting and Inspecting Engineers

Hugh W. Skidmore
Gene Abson
Materials, Processes, Structures, Consultation, Inspection, Testing, Design, Research, Investigation and Experts in Litigation.
536 Lake Shore Drive.
Chicago.

H. O. Chute

Chemical Engineer

Stream Pollution and Trade Waste Problems Handled from the Standpoint of Recovery of Products. Specialist in Multiple Effect Evaporation.
50 East 41st Street,
New York City.

Clark, Wm. G.

Civil and Sanitary Engineer

Hydraulic, Sanitary and Municipal Engineering, Power Developments, Expert Examinations and Reports.
Toledo, O., 1046 Spitzer Bldg.

A. W. Dow

Chemical Engineer
Consulting Paving Engineer

A. W. Dow, Ph. B., Mem Am. Inst. Ch. Engrs.
Asphalt, Bitumens, Paving, Hydraulic Cement, Engineering Materials.
301 Second Avenue,
New York City.

Fowler, Charles Evan

Consulting Civil Engineer

M. I. Am. C. E.
M. Eng. Inst., Can.
BRIDGES AND ARTISTIC STRUCTURES.
FINANCING FOR GOOD PROJECTS.
New York City.
5 West 63rd St.

Fuller & McClintock

Engineers

George W. Fuller
James R. McClintock
F. G. Cunningham
C. A. Emerson, Jr.
Elmer G. Manahan
W. Donaldson
E. W. Whitlock
Water Supply, Water Purification, Sewerage, Sewage Disposal, Garbage and Industrial Wastes Problems, Valuation and Rate Regulation of Public Utilities.
New York, 170 Broadway.

Gordon & Bulot

Engineers

Successors to Maury & Gordon.
Water Supply and Purification, Sewerage and Sewage Disposal.
Design, Appraisals, Reports.
Chicago, 53 W. Jackson Blvd.

Hall, B. M., & Sons

Civil, Mining and Hydraulic Engineers

Southern Water Powers
Drainage
Irrigation
Atlanta, Ga., Peters Bldg.

Nicholas S. Hill, Jr.

Consulting Engineer

Water Supply, Sewage Disposal, Hydraulic Developments, Reports, Investigations, Valuations, Rates, Design, Construction, Operation, Management, Chemical and Biological Laboratories.
112 East 19th St., New York

A. Elliott Kimberly

Consulting Sanitary Engineer

Water Supply, Water Purification, Water Softening, Sewerage, Sewage Disposal, Sewage Treatment, Waste Treatment, Specialists in Milk and in Canning Waste Treatment.
568 East Broad St., Columbus, Ohio.

Morris Knowles, Inc.

Engineers

Water Supply and Purification, Sewerage and Sewage Disposal, Valuations, Laboratory, City Planning.
Pittsburgh, Pa.

Metcalf & Eddy

Engineers

Water, Sewage, Drainage Refuse and Industrial Wastes Problems, Laboratory, Valuations.
Statler Bldg., Boston.

Sheppard T. Powell

Chemical Engineer

Treatment of Water for Industrial Uses.
Trade Waste Investigations and Correction.
Technical Expert in Litigations.
213 St. Paul Place,
Baltimore, Maryland.

Potter, Alexander, C. E.

Hydraulic Engineer and Sanitary Expert

Sewerage and Sewage Disposal, Water Supply and Purification.
New York, 50 Church St.
Cortlandt 3195.

Malcolm Pirnie

Engineer

Malcolm Pirnie,
Charles F. Ruff.
Water Supply, Treatment.
Sewerage Reports, Plans, Estimates.
Supervision and Operation.
Valuation and Rates.
25 W. 43rd St., New York, N. Y.

Astrid S. Rosing, Inc.

Sewer Pipe.
Drain Tile.
Steam and Electric Conduits.
Building Tile.
Fire Brick.
3464 N. Clark St., Chicago, Ill.

P. H. Taylor Audit Co.

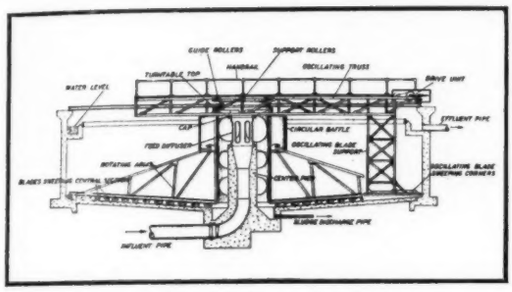
Municipal Accountants and Auditors

Audits.
Systems.
Budget Preparation.
Investigations.
267 Highland Ave., Buffalo, N. Y.

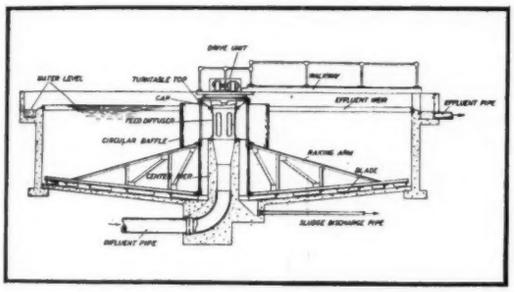
CAPACITY • EFFICIENCY • APPEARANCE • ADAPTABILITY

THE DORR SIFEED CLARIFIER

IS SUITED TO EVERY PLANT CONDITION



The Dorr Sifeed Clarifier with traction drive and square tank



The Dorr Sifeed Clarifier with central drive and round tank

Write for further details

DORRCO

The Dorr Sifeed Clarifier is not a cut and dried, super standardized unit. A flexible versatile design permits its being "tailor made" and adapted to the special types of tank construction favored by different consulting engineers and municipal officials.

- Round tanks, if you prefer them, with central, siphon feed, central drive and overflow across a circular peripheral weir.
- Square tanks, if they best suit your conditions, with central siphon feed; tangential, traction drive and overflow across a square peripheral weir.
- Square or polygonal-topped tanks with round bottoms, too, if you care to go in for unusual arrangements.
- Feed the clarifier from any point of the compass through an underground pipe, terminating at the base of the central siphon.
- Discharge from any point on the side through a pipe terminating in the peripheral overflow channel.

Adaptability is but one of the many distinctive features of the Dorr Sifeed Clarifier. Let us tell you about the others—capacity, appearance, efficiency, less installation and construction cost, and many others.

THE DORR COMPANY, INC.

ENGINEERS • 247 PARK AVENUE, NEW YORK

DENVER CHICAGO LOS ANGELES TORONTO

Affiliated with OLIVER UNITED FILTERS INC. Engineers

Dorr technical services and equipment are available from the following companies:

HOLLAND: Dorr-Oliver N. V. The Hague
FRANCE: Soc. Dorr-Oliver, Paris
ENGLAND: Dorr-Oliver Company Ltd., London
AUSTRALIA: Crossle & Duff Pty. Ltd., Melbourne
SOUTH AFRICA: Edward L. Bateman Pty. Ltd., Johannesburg
GERMANY Dorr-Oliver Gesellschaft, m. b. H. Berlin
JAPAN: Andrew & George Co. Inc., Tokyo

ARE YOU PAYING to be MYSTIFIED?

"The Only Safe Water is a Sterilized Water"

Are you taking advantage of the R. F. C. Loans for self-liquidating projects

?

AS ENTERTAINMENT it's worth paying money to be mystified by a clever magician pulling white rabbits out of a silk hat. But—there's no entertainment in being mystified by the internal ailments of a housed-in chlorinator. That's why we suggest W & T Visible Vacuum Control chlorinators for your plant. All the working parts are under the glass bell jar in full view — with no chance for minor operating irregularities to develop into major repair problems.

For that reason, if for no other, you may count on low maintenance costs, satisfactory operation and long life from W & T Visible Vacuum Control equipment.

And this is equally true whether your problem be one of water sterilization, swimming pool disinfection, sewage treatment or any of the allied sanitary and industrial processes of chlorination.

A card will bring you the details.

WALLACE & TIERNAN CO., Inc.

Manufacturers of Chlorine and Ammonia Control Apparatus

Branches in Principal Cities NEWARK, NEW JERSEY Main Factory: Belleville, N. J.